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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
09/975,458	10/11/2001	Gordon T. Brown	47781-6	9828

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Alan G. Towner
Pietragallo, Bosick & Gordon
One Oxford Centre, 38th Floor
301 Grant Street
Pittsburgh, PA 15219

EXAMINER	
CHARLES, DEBRA F	

ART UNIT	PAPER NUMBER
3624	

DATE MAILED: 02/08/2005

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No.	Applicant(s)	
	09/975,458	BROWN, GORDON T.	
	Examiner	Art Unit	
	Debra F. Charles	3628	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☒ Responsive to communication(s) filed on *October 29, 2004*.

2a)☒ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☒ Claim(s) *28-70* is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☒ Claim(s) *28-70* is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449 or PTO/SB/08) Paper No(s)/Mail Date *11/2/2004*.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other: _____.

Response to Amendment

1. Claims 28,30,35,37,38,39,40,41,42,45,51,53,55,57,59,61,63,65,67,69, and 70 have been amended.

Response to Arguments

2. Applicant's arguments filed October 29, 2004 have been fully considered but they are not persuasive. As per the 101 rejection, technology must be incorporated within the claims and be an inherent part of the invention such that the invention can not operate without technology. The examiner recommends the attorney incorporate technology terms that clearly indicate the invention can not operate without the technology because the patent can not be issued on an abstract idea.

3.The examiner understands the attorney has changed the claims to overcome the prior art disclosed via the Appeals Board decision of August 15, 2001, but the examiner has located other prior art missed in the previous application 08313988 review. Specifically, the examiner has located an accounting information systems textbook (Cushing, Barry E. et al. *Accounting Information Systems: A Comprehensive Approach*, 1990,

Addison-Wesley Publishing Company, 5th Edition) that reflects the applicant's invention and was published in 1990 prior to the applicant's priority date.

4.The examiner does not find any distinction between the term "entity" and "user" in the specification and therefore construes the terms to mean the same thing and to be interchangeable.

5.Cushing et al. and the combined references do teach the provision or production of accounting statements for a plurality of users who have conducted separate financial transactions(see chapter 20 The Finance Cycle, esp. page 800 fig. 20.7).

The applied references do teach the provision of transaction codes, including standardized codes representing financial transaction information, and producing an accounting statement for each user derived from the financial transaction information including income, expense, asset and/or liability for each user (see page 13, i.e. classifying data which involves assigning identification codes (account number, department number, etc.) to data records based on a predetermined system, such as a chart of accounts, page 74-83, i.e. coding techniques; And all of chapter 8, File and

Data Base Approaches to Data Storage, page 800 in chapter 20, The Finance Cycle, esp. Fig. 20.7 which shows a balance sheet and income statements as systems outputs. Balance sheet and income statements inherently display income, expense, asset and or liability since this is the classic old and well-known format to display financial data in Generally Accepted Accounting Practice(GAAP)).

The applied references do teach the transmission of a record of transactions and transaction codes via an open network to at least one file(see page 13, i.e. transmitting data from one location to another, All of chapter 7 Data Communications and Advanced Systems, esp. page 207, 222 a standard network architecture is an open network(standardized protocols) and Fig. 7.22, i.e. with EDI, EDI is inherently an open network. It is well-known that an open network refers to standardized network protocols.).

The applied references do teach transferring data between one entity and another entity on an open communications network(see all of chapter 7 and 8).

Claim Rejections - 35 USC § 101

6. 35 U.S.C. 101 reads as follows:

> Whoever invents or discovers any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof, may obtain a patent therefor, subject to the conditions and requirements of this title.

Claims 28-70 are rejected under 35 U.S.C. 101 because the bodies of the claims do not recite technology, i.e. computer implementation or any other technology in a non-trivial manner. *In re Toma*, 197 USPQ 852 (CCPA 1978). *Ex parte Bowman* 61 USPQ2D 1669.

For a claim to be statutory under 35 USC 101 the following two conditions must be met:

1) The claimed invention must produce a "useful, concrete, tangible result" (In *re Alappat*, 31USPQ2d 1545, 1558 (Fed. Cir. 1994) and *State Street vs. Financial Signature Group Inc.*, 47 USPQ2d 1596' 1601-02 (Fed Cir. 1998));

AND

2) The claimed invention must utilize technology in a non-trivial manner (*Ex parte Bowman*, 61 USPQ2d 1665, 1671 (Bd. Pat. Pat. App. & Inter. 2001)).

As to the technology requirement, note MPEP 2106 IV B 2(b). Also note In *re Waldbaum*, 173USPQ 430 (CCPA 1972) which teaches "useful arts" is synonymous with "technological arts". In *Musgrave*, 167USPQ 280 (CCPA 1970), In re Johnston, 183USPQ 172 (CCPA 1974), and In *re Toma*, 197USPQ 852 (CCPA 1978), all teach a technological requirement.

In State Street, "in the technological arts" was never an issue. The invention in the body of the claim must recite technology. If the invention in the body of the claim is not tied to technological art, environment, or machine, the claim is not statutory. *Ex parte Bowman* 61USPQ2d 1665,1671 (BD. Pat. App. & Inter.2001)(Unpublished).

Claim Rejections - 35 USC § 102

7. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless –
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

8. Claim 28,32,39,40,51,55, and 59 are rejected under 35 U.S.C. 102(b) as being anticipated by Barry E. Cushing and Marshall B. Romney, *Accounting Information Systems: A Comprehensive Approach*, 5th ed. 1990(hereinafter referred to as Cushing et al).

Re claims 28, 51, 55 and 59: Cushing et al. disclose a method, computer readable medium and apparatus of providing financial accounting statements for a plurality of users(page 6, i.e. under the heading The Role of the Accounting Information System, page 269 where the paragraph starts with the word "users"), comprising:

providing transaction codes, including standardized codes representing financial transaction information(page 13, i.e. classifying data which involves assigning identification codes (account number, department number, etc.) to data records based on a predetermined system, such as a chart of accounts, page 74-83, i.e. coding techniques);

each of the users conducting with a plurality of other entities separate financial transactions(page 20, i.e. a typical business entity will engage in a large volume of transactions, which may be greatly varied.);

associating at least one of the transaction codes at about the time when funds are transferred or instructions are given for transfer to complete each financial transaction(Pages 62-63, i.e. transaction data captured in machine-readable form at their time and place of origin. And transactions may be classified into four general types, Fig. 3.1, page 65, Fig. 3.3, i.e. transaction file has account number associated with the transaction, page 77-83, i.e. block coding is usually applied to the major account codes and often to the divisional and departmental codes as well);

transmitting a record of each transaction and the at least one transaction code via an open network to at least one file(page 13, i.e. transmitting data from one location to another, All of chapter 7 Data Communications and Advanced Systems, esp. page 207, 222 a standard network architecture is an open network(standardized protocols) and Fig. 7.22, i.e. with EDI, EDI is inherently an open network. It is well-known that an open network refers to standardized network protocols.); and

sorting the transactions in the at least one file and producing an accounting statement for each user derived from the financial transaction information including income, expense, asset and/or liability information for each user(page 13, i.e. sorting data, which involves arranging a batch of input records into some desired numerical or alphabetical sequence, and pages 22-23, i.e. preparation of financial information, and all of chapter 8, File and Data Base Approaches to Data Storage, page 800 in chapter 20, The Finance Cycle, esp. Fig. 20.7 which shows a balance sheet and income statements as systems outputs. Balance sheet and income statements inherently display income, expense, asset and or liability since this is the

classic old and well-known format to display financial data in Generally Accepted Accounting Practice(GAAP)).

Re Claim 32: Cushing et al. disclose the standardized codes comprise financial transaction codes(page 13, i.e. classifying data which involves assigning identification codes (account number, department number, etc.) to data records based on a predetermined system, such as a chart of accounts).

Re Claim 39: Cushing et al. disclose providing a subsidiary ledger for each of said other entities(page 20, under Purchasing of Assets and Services, the ledgers inventory, fixed asset, expenses and accounts payable are all subsidiary ledgers, page 24, detailed ledgers are subsidiary ledgers); and transferring selected subsidiary ledgers from said other entities to said at least one file(page 13, i.e. transmitting data from one location to another, Fig. 7.22, i.e. with EDI, page 257 under the paragraph that starts with " Similar records are grouped together to form a file (or data set).").

Re Claim 40: Cushing et al. disclose providing access to said subsidiary ledger for said users and/or agents of said users, whereby said users and/or agents can perform one or more activities selected from the group consisting of entering, deleting, reviewing, adjusting and processing said data inputs in said selected subsidiary ledgers(page 13-14, under the data preparation stage and the following paragraphs, lists various data processing functions, all of chapter 8 Data Base and File-Oriented Systems, esp. page 259, where the text starts with ". . . the data and the application programs . . . The person responsible for creating, updating, maintaining and controlling the data base is the data base administrator (DBA), and page 266 where it reads "The data manipulation language (DML) is used to update, replace, store, retrieve, insert, delete, sort, and otherwise manipulate the records and data items." These are de facto data processing functions. And page 267, where it reads "The functions of a DBMS may be divided into three board categories: creation, maintenance, and interrogation." These are also de facto data processing functions.).

Claim Rejections - 35 USC § 103

9.The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

10.Claims 29, 30, 31, 33, 34, 35, 36, 37, 41, 42, 43, 44, 45,47, 52,53,54, 56, 57, 58, 60, 61, 62, and 63 are rejected under 35 U.S.C. 103(a) as being unpatentable over Cushing et al. and Braun et al.(U.S.PAT. 4321672A).

Cushing et al. disclose(s) the claimed invention except the separate financial transactions include the transfer of funds and the instructions for transfer of funds; at least one transaction code is selected by at least one of the users; at least one transaction code is selected by at least one of the other entities; the transmission of the record of each transaction and at least one transaction code is initiated at about the time when funds are transferred or instructions are given for the transfer of funds; the transaction codes are provided from a menu; entering into said file

information regarding at least one of the users; said information includes beginning balances for income, expenses, assets, liabilities and/or bank accounts; entering into said file coding information appropriate to at least one of the users; providing a funds transfer facility to facilitate transfer of funds to and from said first entity and said other entities; and employing said funds transfer facility to receive an instruction to transfer funds; transferring funds from said at least one of said users to said other entities based on said instruction; employing said funds transfer facility to transmit data related to said transfer of funds; and employing said funds transfer facility to adjust current records; and a first computer having at least one file from which an accounting statement may be generated; a second computer for receiving data inputs, said data inputs including electronically recorded financial transaction information made between said first entity and a second entity; an open communication network for transferring said data inputs from said second computer to said file of said first computer.

However, in Abstract, Fig. 4, col. 2, lines 25-67, col. 3, lines 25-67, col. 4, lines 35-60 thereof, Braun et al. disclose(s) electronic funds transfer from a

plurality of terminals with wire instructions(authorization message and reference number); transaction codes selected by various entities, and transmitting a record of the transaction(parallel documented audit trail); and the transaction codes are provided from a menu in Fig. 4; in addition to transfers of data, funds and financial statements from one entity to another entity.

It would be obvious to one of ordinary skill in the art to modify the invention of Cushing et al. based on the teachings of Braun et al. The motivation to combine these Cushing et al. and Braun et al. references is to electronically send funds from one point to another so that the transaction can be performed efficiently in the financial institution. It should be noted that sending electronic funds with instructions is old and well-known in the automated clearing house art. It would be obvious to send instructions to identify the source of funds, bank, and what the funds represent(interest on a bond, dividends on a stock, etc.).

Re Claim 45: Cushing et al. disclose a means for performing two or more activities selected from the group consisting of entering, deleting, reviewing, adjusting and processing said data inputs, and producing said

accounting statement derived from the financial transaction information including income, expense, asset and/or liability information for the first entity(page 13, i.e. sorting data, which involves arranging a batch of input records into some desired numerical or alphabetical sequence, and pages 22-23, i.e. preparation of financial information, and all of chapter 7 Data Communications and Advanced Systems, all of chapter 8, File and Data Base Approaches to Data Storage, page 800 in chapter 20, The Finance Cycle, esp. Fig. 20.7 which shows a balance sheet and income statements as systems outputs. Balance sheet and income statements inherently display income, expense, asset and or liability since this is the classic old and well-known format to display financial data in Generally Accepted Accounting Practice(GAAP). The means is provided via the communications network and database).

11.Claim 38 is rejected under 35 U.S.C. 103(a) as being unpatentable over Cushing et al. and Sloan et al.(U.S.PAT. 5146067A).

Cushing et al. disclose(s) the claimed invention except said users and/or agents of users a passcodes to permit access to said at least one file. However, in the Abstract, col. 7, lines 55-col. 8, line 67, col. 9, lines 30-50,

col. 10, lines 30-60,col. 18, lines 1-25,col. 19, lines 15-40 thereof, Sloan et al. disclose(s) password access to computer files. It would be obvious to one of ordinary skill in the art to modify the invention of Cushing et al. based on the teachings of Sloan et al. The motivation to combine these Cushing et al. and Sloan et al. references is to enhance the security of the accounting computer system by limiting access to authorized individuals.

12.Claims 46,48,49 and 50 are rejected under 35 U.S.C. 103(a) as being unpatentable over Cushing et al. and Braun et al. as applied to claim 45 above, and further in view of Marks (U.S. PAT. 5117356A).

Re Claims 46,49, and 50: Cushing et al. and Braun et al. disclose(s) the claimed invention except a first said file in said first computer for receiving accrual accounting data inputs; and a second said file in said first computer for receiving cash accounting data inputs; And first and second computer is a personal computer. However, in the Abstract, Figs. 1, item 14, col. 2, lines 45-60, col. 3, lines 55-67,col. 13, lines 20-50 thereof, Marks disclose(s) computers receiving cash and accrual based accounting data from a PC. It would be obvious to one of ordinary skill in the art to modify the

invention of Cushing et al. and Braun et al. based on the teachings of Marks. The motivation to combine these references is enhancing the system of Cushing et al. and Braun et al. to reflect cash and accrual accounting techniques automated using a PC.

Re Claim 48: Cushing et al. disclose said second computer comprises means for electronically recording, collecting, processing, storing and transmitting said financial transactions(page 13-14, under the data preparation stage and the following paragraphs, lists various data processing functions and page 13, i.e. sorting data, which involves arranging a batch of input records into some desired numerical or alphabetical sequence, and pages 22-23, i.e. preparation of financial information, and all of chapter 7 Data Communications and Advanced Systems, all of chapter 8, File and Data Base Approaches to Data Storage, page 800 in chapter 20, The Finance Cycle, esp. Fig. 20.7 which shows a balance sheet and income statements as systems outputs. Balance sheet and income statements inherently display income, expense, asset and or liability since this is the classic old and well-known format to display financial data in Generally Accepted Accounting Practice(GAAP). The means is provided via the communications network and database).

13.Claim 63 is rejected under 35 U.S.C. 103(a) as being unpatentable over Cushing et al. as and Matsushita et al.(U.S. PAT. 4837556A).

Cushing et al. disclose(s) the claimed invention as per claims 28,32,39,40, 51,55, and 59 as above except data signal embodied in a carrier wave. However, in col. 21, lines 5-25 and col. 22, lines 1-45 thereof, Matsushita et al. discloses a signal transmission device using carrier waves which is well known in the art. It would be obvious to one of ordinary skill in the art to modify the invention of Cushing et al. based on the teachings of Matsushita et al. The motivation to combine these references is to provide a means for data transmission that effectively transfers into computer technology.

14. Claims 64,65 and 66 are rejected under 35 U.S.C. 103(a) as being unpatentable over Cushing et al. and Matsushita et al. as applied to claim 63 above, and further in view of Braun et al.

Cushing et al. and Matsushita et al. disclose(s) the claimed invention except wherein the separate financial transactions include the transfer of funds and the instructions for transfer of funds; at least one transaction

code is selected by at least one of the users; and wherein the standardized codes comprise financial transaction codes.

However, in Abstract, Fig. 4, col. 2, lines 25-67, col. 3, lines 25-67, col. 4, lines 35-60 thereof, Braun et al. disclose(s) electronic funds transfer from a plurality of terminals with wire instructions(authorization message and reference number); transaction codes selected by various entities, and transmitting a record of the transaction(parallel documented audit trail); and the transaction codes are provided from a menu in Fig. 4; in addition to transfers of data, funds and financial statements from one entity to another entity. It would be obvious to one of ordinary skill in the art to modify the invention of Cushing et al. and Matsushita et al. based on the teachings of Braun et al. The motivation to combine these Cushing et al., Matsushita et al. and Braun et al. references is to electronically send funds from one point to another so that the transaction can be performed efficiently in the financial institution. It should be noted that sending electronic funds with instructions is old and well-known in the automated clearing house art. It would be obvious to send instructions to identify the source of funds, bank, and what the funds represent(interest on a bond, dividends on a stock, etc.).

15.Claim 67, 68 and 69 are rejected under 35 U.S.C. 103(a) as being unpatentable over Cushing et al. and Braun et al.

Cushing et al. disclose(s) the claimed invention except providing a second computer for receiving data inputs, said data inputs including electronically recorded financial transaction information made between said first entity and a second entity; And further including transferring funds from said first entity to said second entity.

However, in Abstract, Fig. 4, col. 2, lines 25-67, col. 3, lines 25-67, col. 4, lines 35-60 thereof, Braun et al. disclose(s) electronic funds transfer from a plurality of terminals(first and second entities) with wire instructions(authorization message and reference number); transaction codes selected by various entities, and transmitting a record of the transaction(parallel documented audit trail); and the transaction codes are provided from a menu in Fig. 4; in addition to transfers of data, funds and financial statements from one entity to another entity.

It would be obvious to one of ordinary skill in the art to modify the invention of Cushing et al. based on the teachings of Braun et al. The motivation to combine these Cushing et al. and Braun et al. references is to electronically send funds from one point to another so that the transaction can be performed efficiently in the financial institution. It should be noted that sending electronic funds with instructions is old and well-known in the automated clearing house art. It would be obvious to send instructions to identify the source of funds, bank, and what the funds represent(interest on a bond, dividends on a stock, etc.).

16.Claim 70 is rejected under 35 U.S.C. 103(a) as being unpatentable over Cushing et al., Matsushita et al. and Braun et al.

Cushing et al. disclose(s) the claimed invention as per claims 28,32,39,40, 51,55, and 59 as above except data signal embodied in a carrier wave. However, in col. 21, lines 5-25 and col. 22, lines 1-45 thereof, Matsushita et al. discloses a signal transmission device using carrier waves which is well known in the art. It would be obvious to one of ordinary skill in the art to modify the invention of Cushing et al. based on the teachings of Matsushita

et al. The motivation to combine these references is to provide a means for data transmission that effectively transfers into computer technology.

Cushing et al. and Matsushita et al. disclose(s) the claimed invention except providing a second computer for receiving data inputs, said data inputs including electronically recorded financial transaction information made between said first entity and a second entity; And further including transferring funds from said first entity to said second entity.

However, in Abstract, Fig. 4, col. 2, lines 25-67, col. 3, lines 25-67, col. 4, lines 35-60 thereof, Braun et al. disclose(s) electronic funds transfer from a plurality of terminals(first and second entities) with wire instructions(authorization message and reference number); transaction codes selected by various entities, and transmitting a record of the transaction(parallel documented audit trail); and the transaction codes are provided from a menu in Fig. 4; in addition to transfers of data, funds and financial statements from one entity to another entity.

It would be obvious to one of ordinary skill in the art to modify the invention of Cushing et al. and Matsushita et al. based on the teachings of Braun et al. The motivation to combine these Cushing et al., Matsushita et al. and Braun et al. references is to electronically send funds from one point to another so that the transaction can be performed efficiently in the financial institution. It should be noted that sending electronic funds with instructions is old and well-known in the automated clearing house art. It would be obvious to send instructions to identify the source of funds, bank, and what the funds represent(interest on a bond, dividends on a stock, etc.).

17. Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory

period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Debra F. Charles whose telephone number is (703) 305-4718. The examiner can normally be reached on 9-5 Monday thru Friday.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Vincent A. Millin can be reached on (703) 308-1065. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9306.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

VINCENT MILLIN
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 3600

Debra F. Charles
Examiner
Art Unit 3624

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VINCENT MILLIN
SUPERVISORY PATENT EXAMINER
TECHNOLOGY CENTER 3600

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Fifth Edition

Accounting Information Systems

A Comprehensive Approach

Barry E. Cushing
The Pennsylvania State University

Marshall B. Romney
Brigham Young University

ADDISON-WESLEY PUBLISHING COMPANY

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Chapter 7

Data Communications and Advanced Systems

Learning Objectives

After studying this chapter, you should be able to:

- ◇ Explain the fundamental concepts of data communications systems.
- ◇ Identify the hardware and software typically found in data communications systems and explain how they operate.
- ◇ Compare and contrast alternative communications channels, communications channel configurations, and data communications carriers.
- ◇ Compare and contrast the following data communications networks: centralized, distributed processing, local area, and public data.
- ◇ Describe a number of common data communications applications and explain how the data communications model elements are combined to meet the user's needs.

Chapter Outline

Businesses need to be able to make quick and efficient decisions based on timely and accurate information. As businesses become more complex and geographically dispersed, the problems of data collection, processing, and communication increase, yet the need for information intensifies. Many organizations are finding that communication by letter or even by telephone no longer meets their needs. Instead, they are using computers and communications technology to form **telecommunications systems.** These systems bridge geographical distances, giving authorized users immediate access to a company's computerized data.

Data communications is the transmission of data from a point of origin to a point of destination. Data communications systems, which typically transmit data over communications lines or by satellite, have evolved gradually. In the early days of computers, control, efficiency, and personnel considerations, as well as economies of scale, led many organizations to consolidate their systems into one large **centralized data processing system.** As organizations became larger and more diversified, centralization often proved inconvenient. Data had to be transported to the data center, entered into the system, and processed, and then the output had to be returned to the user. To overcome this problem, **teleprocessing systems** (a combination of the words "telecommunications" and "data processing") were introduced. These systems connect computer terminals at various locations to the central computer. The terminals are used to input data and to receive output, and the centralized computer continues to do all the data processing. Although these systems solved some of the input/output problems, they were unable to meet all the needs of geographically dispersed users.

When minicomputers were introduced, they were placed in remote locations within an organization and linked to a centralized computer to form a **distributed data processing** (DDP) system. DDP systems provide organizations with a great deal of flexibility. Each remote computer can (1) act as a terminal, or input device, in a teleprocessing system; (2) meet the specific processing needs of the remote location and communicate summary results to the centralized (host) system; or (3) be a self-contained system. Microcomputers have further fueled the trend toward DDP systems. They have also resulted in the development of local area networks (LANs) and micro-to-mainframe links (MMLs). (These data communications systems are discussed later in the chapter.)

Data communications technology is important in the development and operation of accounting information systems. Accountants must understand data communications fundamentals, such as the hardware and software used, the types of data communications systems, and how these systems are used. This chapter provides a basic understanding of these topics, which are becoming increasingly important to accountants as they use, audit, and help select data communications systems.

Fundamental Data Communications Concepts

Before specific data communications configurations, approaches, and uses can be discussed, certain communications concepts must be understood. This section introduces these concepts.

A Data Communications System Model

As shown in Fig. 7.1, a data communications system consists of five major components: the sending device, the communications interface device, the communications channel, the receiving device, and communications software. The figure also lists some common devices and communications channels.

A data communications system transmits data from one location (the source) to another (the receiver). For example, a remote terminal transmits data to a centralized computer for processing. The data to be transmitted, called the **message,** are entered into the sending terminal and stored. When the terminal is ready to transmit the message, a communications interface device such as a modem converts the input message to signals that can be transmitted over a communications channel such as a telephone line. At its destination another communications interface device converts the message back into internal computer code and forwards it to the receiving computer. When the receiving unit sends a message back to the source to verify that the message has been received, the communications process is reversed. Communications software controls the system and manages all communications tasks. The capacity and speed of data transmission are measured by how many **bits per second** (bps) are transferred.

Transmission Concepts

Messages can be transmitted in a number of ways. Depending on the hardware and the data communications system configuration in use, transmission signals may be analog or digital; serial or parallel; asynchronous or synchronous; or simplex, half-duplex, or full-duplex. The transmission method used will determine the speed, cost, and reliability of data transmission.

Computers store data internally in discrete, or **digital,** form as the presence or absence of an electronic pulse. The communications channels used most frequently, like ordinary telephone lines, send signals in **analog** (or wave) form. As explained in Chapter 6, data transmitted over telephone lines often must be con-

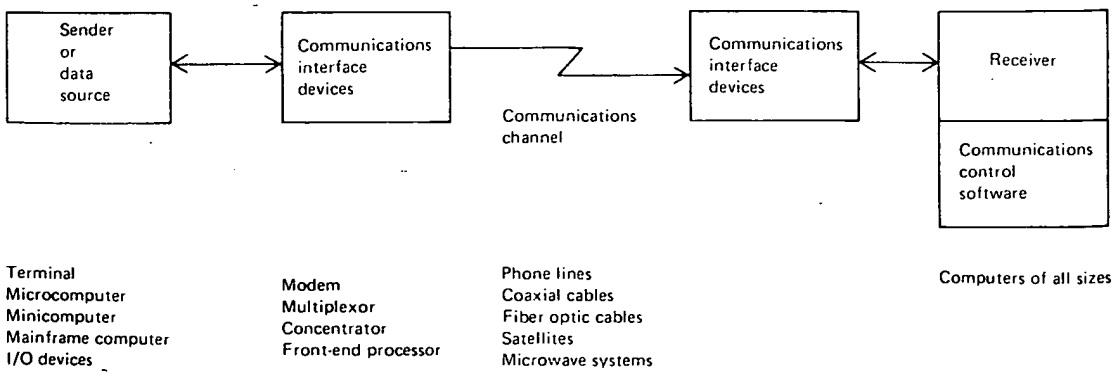


Figure 7.1
The five components of a data communications system.

verted into analog signals using a modem. However, data can also be transmitted in digital form. Transmitting data in digital form (as distinct electronic pulses) has a number of advantages. Digital transmission is faster and more efficient, is less error prone, and does not require a modem since the modulation/demodulation process is unnecessary. Digital transmission, however, has a number of problems that limit its use. Digital data transmission is often more expensive and more difficult, because the signals drop in intensity as a result of the physical resistance offered by the lines. Digital transmission equipment is not as readily available as analog equipment, because it has only recently come into widespread use. Although some lines accept digital transmissions directly, most lines in use were designed for analog signals. Because of these drawbacks, analog transmission is more common than digital transmission. A comparison of analog and digital signals is shown in Fig. 7.2.

Data transmission can be either serial or parallel, depending on the hardware and the communications channel used. With **serial transmission**, bits are transferred one at a time. With **parallel transmission**, two or more bits are transferred at the same time over separate communications channels. Transferring an eight-bit byte serially is like having eight cars travel on a single-lane highway. Transferring the bits eight at a time is like having all eight cars travel abreast down an eight-lane highway. Parallel transmission is used when the increased speed is more important than the added cost of parallel transmission. Figure 7.3 illustrates serial and parallel transmission.

When electronic signals are sent over a communications channel, both the sending and the receiving unit must be in synchronization so that the signals can be interpreted properly. With **asynchronous transmission** (or start/stop transmission), each character is transmitted separately and is preceded by a start bit and followed by a stop bit. With **synchronous transmission**, a block of characters is transmitted, with start and stop bits only at the beginning and end of each group of characters. The beginning and end of each character are determined by the timing mechanisms of the sending and receiving units. Since the timing mechanisms of both devices are "in sync" during the entire transmission, the receiving device knows when each new character begins and ends. The decision as to which method to use usually involves a trade-off among speed, efficiency, and cost. Asynchronous transmission is inexpensive and simple and allows for irregular transmission of data. Synchronous transmission is much faster and more efficient

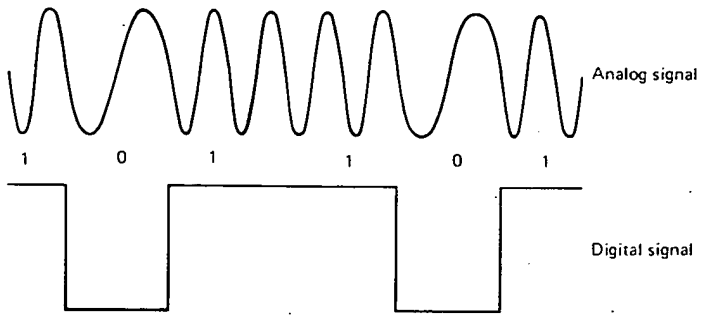


Figure 7.2
Analog and digital signals contrasted.

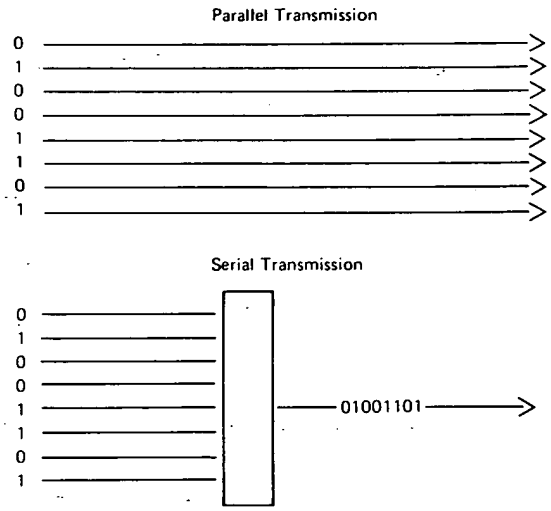


Figure 7.3
Parallel and serial transmission of an eight-bit byte.

but also more expensive. Asynchronous transmission is usually used for low-speed transmissions of less than 2000 bps, and synchronous is used for high-speed transmissions exceeding 2000 bps.

Communications channels provide for three different options with respect to directions of transmission. A **simplex channel** only allows for one-direction communication—that is, the channel can either send or receive signals, but cannot do both. **Half-duplex channels** allow for data transmission in both directions, but only one direction at a time. These channels are sufficient for low-speed data transmission, telephone service, or for use when an immediate response is not necessary. **Full-duplex channels** allow the system to transmit data in both directions at the same time. These channels are used for high-speed data transmission between computers or when real-time processing (immediate responses to data inquiries) is necessary. Figure 7.4 shows the three directional transmissions.

Data Communications Hardware

Data Input Devices

There are a number of hardware devices that can be attached to a communications channel and used to send or receive data from a computer. These include dumb and intelligent terminals; micro-, mini-, and mainframe computers; and

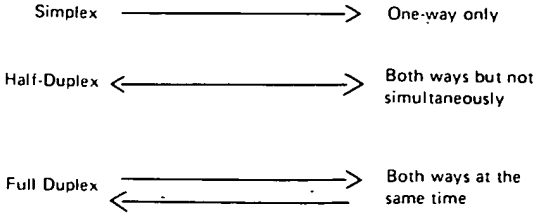


Figure 7.4
Simplex, half-duplex, and full-duplex data transmission.

source data automation devices. These devices have been discussed in previous chapters. Another data communications device is the terminal emulator. A **terminal emulator** is a microcomputer that uses communications software to emulate a dedicated terminal. When not in use as a terminal, the micro can be used as a personal computer.

Communications Interface Devices

Slow-speed devices, such as terminals, typically do not use the full capacity of medium- or high-speed transmission lines. To take advantage of these more expensive lines, a **multiplexor** can be used to combine signals from several sources. These combined signals are then transmitted over the communications channel, and a multiplexor on the other end separates the signals back out into the individual messages. Some multiplexors are able to do so many things that they are called intelligent multiplexors. These multiplexors are able to monitor errors, carry out a variety of data handling and manipulation tasks, temporarily store data, and interface with satellites and other advanced communications networks.

A **concentrator** performs multiplexing tasks as well as a variety of data validation, data formatting, and backup tasks. It uses microprocessor intelligence, storage, and stored programs to store, merge, and control messages from a variety of input devices. Concentrators are generally more powerful and expensive than multiplexors. In addition, they generally store signals until they are complete and then forward them over the high-speed line rather than transmit bits and pieces of messages as multiplexors do.

The principal advantage of multiplexors and concentrators is that transmission speeds are increased, which reduces the time the central processor and the terminals have to sit idle waiting for messages to be received. Costs are usually reduced because there is less waiting and because only one communications channel is needed for several terminals. Figure 7.5 shows a data communications system without multiplexing, and Fig. 7.6 shows the system with multiplexing. Without multiplexing, each terminal needs a modem at each end of the system and an individual communications channel between them. With multiplexing, only

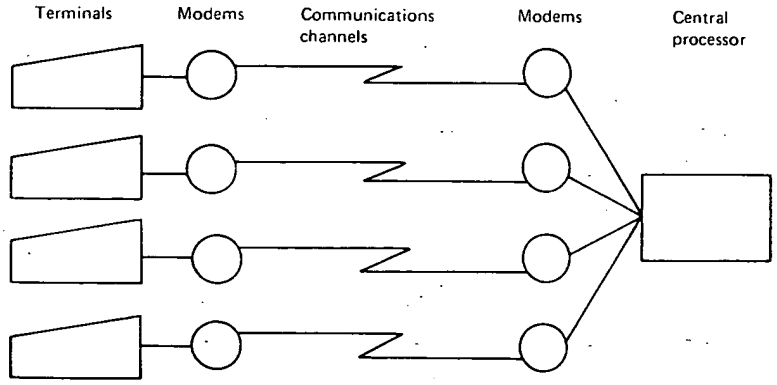


Figure 7.5 *Data communications system without multiplexing.*

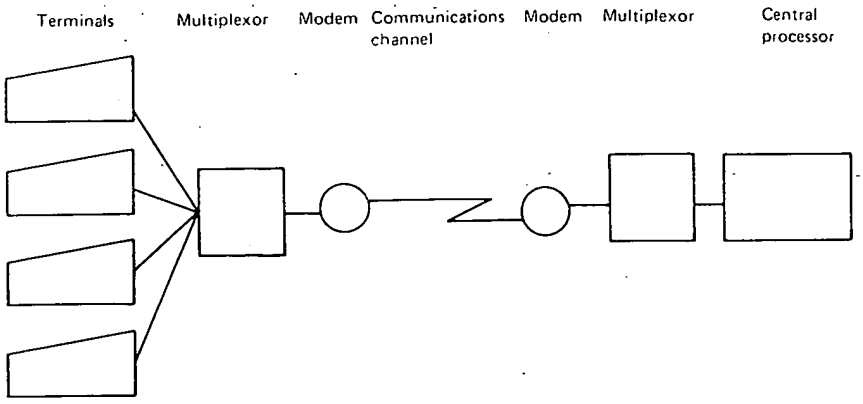


Figure 7.6 *Data communications system with multiplexing.*

one modem is needed at each end and only one channel in between. Cost reductions come from using fewer modems and communications channels. These cost savings, however, may be partially or completely offset by the cost of the multiplexors and the more expensive communications channels needed for multiplexing.

When the volume of data transmission surpasses a certain level, a programmable minicomputer called a **front-end processor** (FEP) or **communication processor** is useful. An FEP can connect a large CPU to hundreds of communications channels. It can also perform communications tasks, such as handling messages and assigning them priorities, restricting access to authorized users, and controlling the interaction between terminals and the CPU, more economically than the CPU. It can edit data, detect and correct errors, and keep a log of all messages sent and received and all errors detected. It can also poll terminals to determine if they are ready to send or receive data, store data until called for by the CPU, validate transmitted data, and preprocess data prior to transmitting to the central computer. In summary, a front-end processor relieves the CPU of time-consuming data communications coordination and control functions and helps it to make more efficient use of its resources.

An FEP provides several advantages, one of the most important of which is increasing the effectiveness of the CPU. Its main disadvantages are extra cost and the increased system complexity that results. The data communications system shown in Fig. 7.6 is revised in Fig. 7.7 to include a communications processor. Note that the multiplexor on the CPU end of the system is replaced by the communications processor.

Data Communications Software

Data communications systems software is usually more complex than conventional systems software because requests for service arrive in unpredictable patterns from many terminals. To cope with the problem, special **communications**

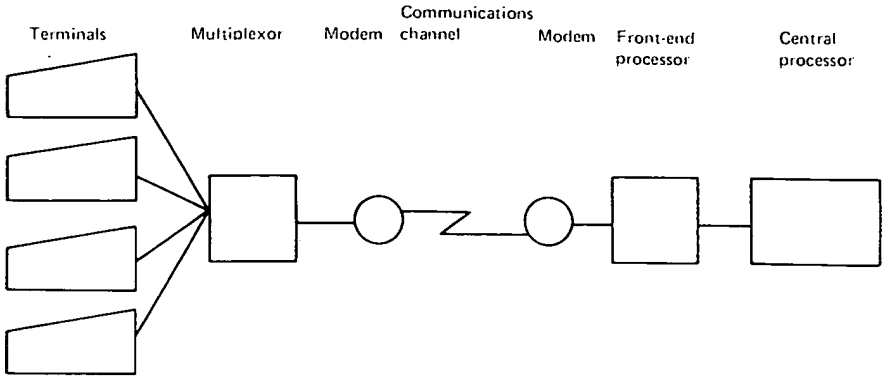


Figure 7.7
Data communications system with a communications processor.

control programs manage the data communications activity and interact with the various terminals. Data communications programs perform the tasks necessary to link two devices and transfer data from one to the other. The control programs may be executed either by the main computer or by a programmable front-end processor. The communications control programs free the operating system from the task of managing data communications, thereby enabling it to more efficiently perform its overall supervisory functions. Figure 7.8 lists some of the many procedures and tasks accomplished by this software.

Users are no longer content to use terminals (or micros that emulate terminals) to access the data base. They want to be able to interactively search for the data they need, download them into their micro, manipulate them to meet their needs, and upload them back into the corporate data base. To do this, special software,

Figure 7.8
Tasks performed by data communications software.

- ◇ Control data transmission features such as baud rate and duplexing.
- ◇ Connect and disconnect communications links by automatically dialing, redialing, answering, and disconnecting. To accomplish these functions, the system must usually store commonly used phone numbers.
- ◇ Poll terminals in the system to see if they are ready to send/receive data.
- ◇ Queue the input entries awaiting processing and the output messages waiting to be sent.
- ◇ Execute tasks according to user-assigned priorities.
- ◇ Route messages in the system to their proper destination.
- ◇ Detect and correct system errors.
- ◇ Log statistics of errors and other system activity.
- ◇ Provide for system security and privacy by means of passwords, encryption, etc..
- ◇ Temporarily store data that have been received or are to be sent.
- ◇ Format messages for forwarding to the central processor or a terminal.
- ◇ Transfer files from one computer to another.
- ◇ Create macros to simplify data communications tasks, such as logging on to an external system.
- ◇ Edit data in a file. In more sophisticated packages, the user can create, delete, edit, and copy files without leaving the communications program.

called a **micro-to-mainframe link** (MML), is needed. There are two parts to MML software—the software resident in the mainframe and the software used by the micro. MML software costs vary depending on whether just one or both of the software components are purchased, how many micros will be linked to the mainframe, and how many modules of the mainframe software are needed.

An MML requires a number of control strategies. Only authorized people should be able to download or upload data. Passwords (with varying clearance levels or hierarchies) and other identifiers are typically used to control access. The content of the data files should also be controlled to ensure that uploaded data are valid and accurate. The data files can be controlled by creating "shadow" files to store the uploaded data. These shadow files are separate from the "live" data bases that are stored on the mainframe. It can also be controlled by using the normal data entry and input controls used in online real-time systems. A third way to control access to data files is simply to not allow the upload process to take place and to require all changes in data to go through the normal data entry process. The whole MML process is still in its infancy, and the industry is struggling to determine how to best operationalize and control it.

Software Conventions, or Protocols

For two computer systems to communicate successfully, the hardware devices and the communications channel must conform to a mutually acceptable set of conventions, called the **protocol.** The protocol is the set of rules governing the exchange of data between the two systems. These rules establish how the systems identify themselves, how data are to be transferred, when the transfer should start and stop, what devices should be involved, how errors should be handled, and so forth. Key elements of a protocol are the format of the data, the codes to be used, the type of signal, control information for coordination and error management, procedures for matching the speeds of systems devices, and the proper sequence of data.

Communications Channels

A **communications channel** is the line or link that connects the sender and the receiver in the data communications network. This connection can be a line that physically connects the two devices, like a coaxial cable, a standard telephone line, or a fiber optics cable. The connection can also be made by terrestrial microwaves, by satellite microwaves, or by cellular radio. This section discusses the various types of channels, channel capacities and speeds, and the companies that market communications links.

Alternative Communications Channels

The communications channel selected can have a significant impact on system reliability, cost, and security. Therefore it is important that the accountant understand the various channels that are available and their characteristics, advan-

tages, and disadvantages. This section provides the perspective needed by those managing or designing a data communications system.

Standard Telephone Lines. Most telephone lines consist of two insulated copper wires, called twisted pairs, that are arranged in a spiral pattern. Large numbers of these pairs are bundled together in large cables wrapped in protective sheaths. Although used primarily for voice, twisted pairs can be used to transmit both analog and digital signals. For analog signals, amplifiers are needed on the line at frequent intervals to boost the signal. For digital signals, repeaters are needed at even more frequent intervals to recover the original pattern of on-off pulses and transmit a new signal. Telephone lines are the most convenient communications channel, because large numbers of them are already installed.

Coaxial Cable. A **coaxial cable** is a group of copper and aluminum wires that are wrapped and insulated to minimize interference and signal distortion. These cables are usually buried underground or placed on the ocean floor. Coaxial cable is used in long-distance telephone networks; a single cable can carry as many as 15,000 calls simultaneously. Local area networks use coaxial cable because it can support a large number of devices having a variety of data and traffic types. Coaxial cable is also used for short-range connectors between computing devices. Coaxial cable can transmit both analog and digital signals. It can be used at higher frequencies and data rates than can twisted pairs and is less susceptible to interference and cross talk. For long-distance transmission of analog and digital signals, amplifiers or repeaters are needed every few kilometers. Data transmission rates as high as 800 million bps have been achieved with digital signals.

Fiber Optics. A **fiber optics cable** consists of thousands of tiny filaments of glass or plastic that transmit data using light waves. The light waves, which are generated by lasers, are very concentrated and of high frequency. There are many advantages to fiber optics cables. They are much faster, smaller, lighter, and less expensive than coaxial cables. Speeds of up to several billion bits per second are possible. A transmission that takes an hour on copper wires can be accomplished in less than a second using fiber optics. A fiber optics cable can contain up to ten times more channels and weigh up to ten times less than a coaxial cable of the same size. Fiber optics cables do not require messages to be amplified or rebroadcast nearly as frequently. Optical fibers are practically immune to electrically generated noise and cross talk and therefore have a lower error rate. Fiber optics cables have a very high resistance to wire taps and offer much higher levels of security. They operate at temperatures that would melt copper cables. Notwithstanding their many advantages, fiber optics cables are not likely to surpass telephone lines and coaxial cables as the most frequently used transmission medium since there are just too many copper wires in use. However, it is estimated that by the early 1990s fiber optics cables will be carrying 35 percent or more of the traffic now carried on telephone and coaxial cables.

Terrestrial Microwave Systems. **Terrestrial microwave** is a medium frequently used for long-distance data or voice transmission. It does not require the

laying of expensive cable; instead, long-distance dish or horn antennas with microwave repeater stations are placed approximately twenty-five to thirty miles apart. Each transmitter station receives a signal, amplifies it, and retransmits it to the next station. All the transmitters and receivers must be in a straight line, because the signal cannot bend around the curvature of the earth. Both analog and digital signals can be transmitted over microwave at speeds of up to 500,000 bps.

Communications Satellites. **Satellite microwave** is similar to terrestrial microwave except that instead of being transmitted to another nearby microwave dish antenna, the signal is transmitted to a satellite in space. This satellite acts as a relay station and sends the transmission back to any of the earth stations that care to pick up the signal. A satellite that is placed in orbit approximately 22,000 miles above the earth maintains a fixed position as the earth rotates. This "stationary" satellite is therefore able to send and receive signals from almost 50 percent of the earth's surface. The other 50 percent of the world can be reached by transmitting to a satellite on that side of the world. There are several dozen of these communications satellites currently in use. They are powered by solar panels, weigh several thousand pounds, and are able to transmit microwave signals at a rate of several hundred million bits per second. Unlike that of most other media, the cost of satellite transmissions is independent of the distance the message must be transmitted.

Cellular Radio. By using **cellular radio,** companies can take greater advantage of the number of radio frequencies available. If the area normally covered by a single powerful transmitter is divided into small sections called cells, each with a transmitter, each frequency can be used by different companies in each cell. This allows up to twenty-five times more people to use the radio frequencies. A powerful central computer and sophisticated interface equipment coordinate and control the transmission between cells.

Channel Capacity and Speed

Communications channels are classified in three categories, or bandwidths, according to their information carrying capacity or data transfer rate. **Narrowband,** or subvoice-grade, **lines** operate at speeds of up to 300 bps. They are limited to low-volume applications using devices like teletypewriters and low-speed printing terminals. They are not suitable for transmitting audible or voicelike signals. **Voiceband lines** can be used for voice or data communications. They are typically telephone lines and operate at speeds of from 300 to 9600 bps. Voiceband lines are commonly used to communicate with microcomputers, CRT terminals, and medium-sized printers. **Wideband,** or **broadband, lines** transmit at rates of up to fifty million bps. Their primary use is for high-speed data transmission between computer systems. Coaxial and fiber optics cables, terrestrial microwave systems, and satellites are usually used because of their greater reliability and fewer interferences. The more the user moves toward the use of wideband lines, the greater the volume of data that can be transmitted and the higher the cost.

Voiceband Line Options

Three types of voice-grade telephone line services are available for data communications. These are **leased lines, switched lines** (dial-up service using public lines), and **Wide Area Telephone Service (WATS) lines.** Leased lines, also called dedicated lines, are devoted exclusively to the use of a single customer. The cost is fixed and is determined by the line length. Advantages of leased lines relative to the alternatives include lower error rates, faster rates of data transmission, and increased privacy. Also, leased lines are always connected, so the fifteen- to twenty-second connection time needed with the other options is eliminated.

Both switched lines and WATS lines use the long-distance telephone service available to the general public. The difference between them lies in the rate structure. The cost of switched line service varies in proportion to the amount of time the lines are used. With a WATS line, the user pays a fixed fee to use the line and then pays an additional charge that varies directly with the amount of extra usage. Switched lines are more flexible than leased or WATS lines, because any telephone may be used for data transmission. An advantage of WATS and switched lines is that more than one computer system may be accessed from a single terminal.

A primary consideration in choosing among leased, switched, and WATS lines is cost, which in turn is dependent on both volume of usage and distance between transmission points. At very low volumes of usage, switched line service is usually most economical. At very high volumes of usage, leased lines are usually most economical. A WATS line is usually most economical at intermediate levels of usage. As the distance between transmission points increases, switched lines and WATS lines become less costly than leased lines. Few users depend entirely on one alternative. When leased lines are used, for example, switched lines are often used for backup purposes.

An example should clarify the economic factors affecting the choice among these three alternatives. Consider a company that wishes to connect a remote terminal in Salt Lake City to a processing center 922 miles away in Kansas City. Costs for the three alternative forms of service are as follows.

1. *Leased voice-grade analog line.* There is a fixed monthly line charge of $557.16 plus $0.35 a mile ($322.70), for a total of $879.86 per month. This line can transmit 4800 bps very reliably. For another $105 per month, the line can be conditioned to carry 9600 bps.
2. *Switched line.* The weekday rate for each direct-dialed call is $0.55 for the first minute and $0.38 for each additional minute. Assuming an average of four minutes per call, this works out to an average of $0.4225 per minute, or $25.35 per hour.
3. *WATS line.* It costs $57.65 to connect these two points, plus $19.26 per hour for the first fifteen hours, $17.14 from fifteen to forty hours, $15.04 between forty and eighty hours, and $12.72 for every hour over eighty.

Figure 7.9 graphs the total monthly cost for each of these three alternatives as a function of the number of hours of usage. The graph indicates that switched lines are most economical up to a usage volume of approximately 9.5 hours per

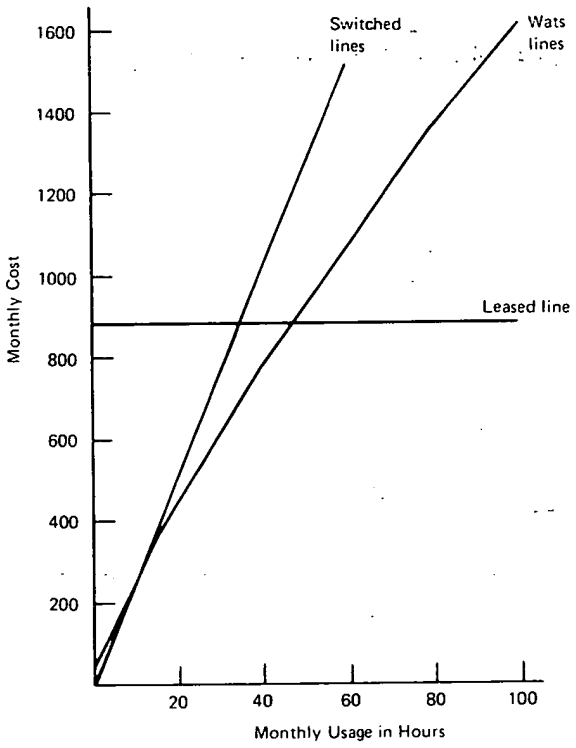


Figure 7.9 *Sample economic comparison of leased lines, switched lines, and WATS lines.*

month. WATS lines are most economical for usage volumes ranging between approximately 9.5 and 47 hours per month. Leased lines are most economical for usage volumes in excess of approximately 47 hours per month. Although the specific break-even points will vary depending on the distance between the two points, the general shape of each of the three cost functions will be as shown in Fig. 7.9. The closer one gets to the break-even points, the more important other factors become. For example, since leased lines are much more reliable, less time is needed for retransmission of erroneous data and for error determination and investigation, and less staff time is required to monitor the data.

Communications Channel Configurations

The communications channels that connect the various points in a data communications system may be configured in a number of ways. The three basic configurations are point-to-point, multidrop, and line-sharing. Assume a central computer is to have several terminals attached. The simplest configuration uses **point-to-point lines,** or one line from each terminal to the central processor, as illustrated in Fig. 7.10. **Multidrop lines,** illustrated in Fig. 7.11, link the terminals to each other, with only one or a few terminals linked directly to the CPU. All

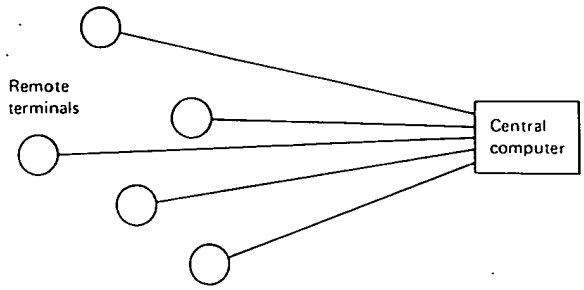


Figure 7.10
Data communications network using point-to-point lines.

other terminals are indirectly linked to the CPU by means of lines that connect through other terminal locations. The use of a **line-sharing device**, in which data from (or to) several terminals are combined for transmission on a single line, is illustrated in Fig. 7.12. In all three figures, the terminals are located in the same place, and therefore the distance between the terminals and the central computer is the same.

Point-to-Point Lines. In a system using point-to-point lines, either leased lines, WATS lines, or switched lines may be employed, whichever is most economical. It is even possible to have a combination of different types of lines within the same network. The primary advantages of the point-to-point configuration are its simplicity in terms of hardware requirements; its availability to users, who are rarely required to wait on others who have tied up the lines; and its reliability in the sense that if a line fails, only one user is affected. The primary disadvantage of this configuration is that it maximizes total line mileage in the network. Since most data communications costs are directly related to line mileage, point-to-point lines are frequently more costly than alternative configurations.

Multidrop Lines. A visual comparison of Fig. 7.10 with Fig. 7.11 indicates the potential for reducing line mileage and data communications costs through the use of multidrop lines. The multidrop configuration does have some disadvantages, however. First, only one terminal at a time can transmit data, which

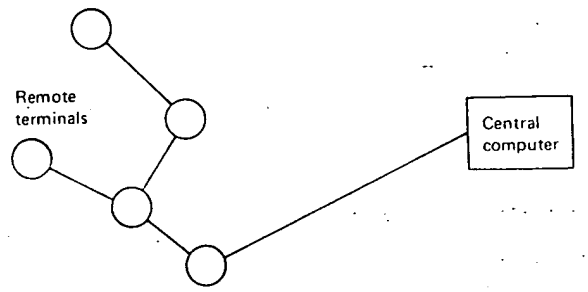


Figure 7.11
Data communications network using multidrop lines.

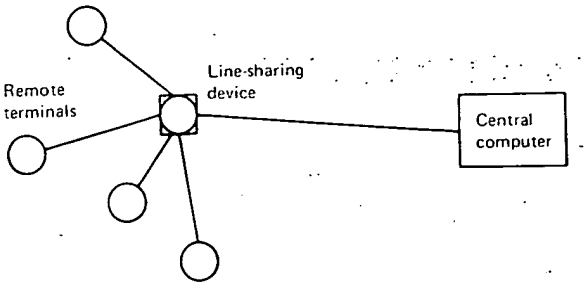


Figure 7.12 *Data communications network using a line-sharing device.*

means that line conflicts must be controlled. With the **polling approach,** the computer asks each terminal on the multidrop line if it has a message to send and then lets each, in turn, transmit data. With the **contention approach,** the terminal "listens" to the line to see if it is in use. If the line is free, the message is transmitted. If it is busy, the terminal waits a predetermined amount of time and then tries again. Polling is frequently used because the central computer can control transmission and keep terminals from monopolizing the line. A second disadvantage of multidrop lines is that all terminals down the line from the point where a line fails are cut off from the central computer. Finally, multidrop lines are the least flexible of the three basic configurations. Usually, all the lines must be leased, whereas switched or WATS lines may be used for some or all connections under the other two alternatives.

Line-Sharing Device. Line-sharing devices, such as multiplexors and concentrators, combine two or more incoming data signals from low-speed lines into one signal and transmit them simultaneously on a single high-speed line. This eliminates or substantially reduces the wait time experienced by users of multidrop lines. A comparison of Fig. 7.10 with Fig. 7.12 shows that line-sharing devices can also reduce the line mileage required in a point-to-point system. The cost savings that result, however, will be partially or wholly offset by the cost of the line-sharing equipment and the more expensive high-speed line that is generally required to connect the line-sharing device to the central computer. System reliability may be a problem in that a failure in the shared line will cause all users to be cut off from the system. Line-sharing systems offer the flexibility of choice among leased, switched, or WATS lines to connect each remote terminal to the line-sharing device. The shared line, however, must be leased.

A large data communications network often contains a combination of all three approaches. The network designer does not simply choose one of the three approaches for the entire network. Instead, the relative advantages and disadvantages of each configuration are evaluated, and the best approach for each individual terminal connection is chosen. Figure 7.13 illustrates a network in which all three approaches are used. This figure also demonstrates the relationships that exist among the various hardware elements within a data communications network.

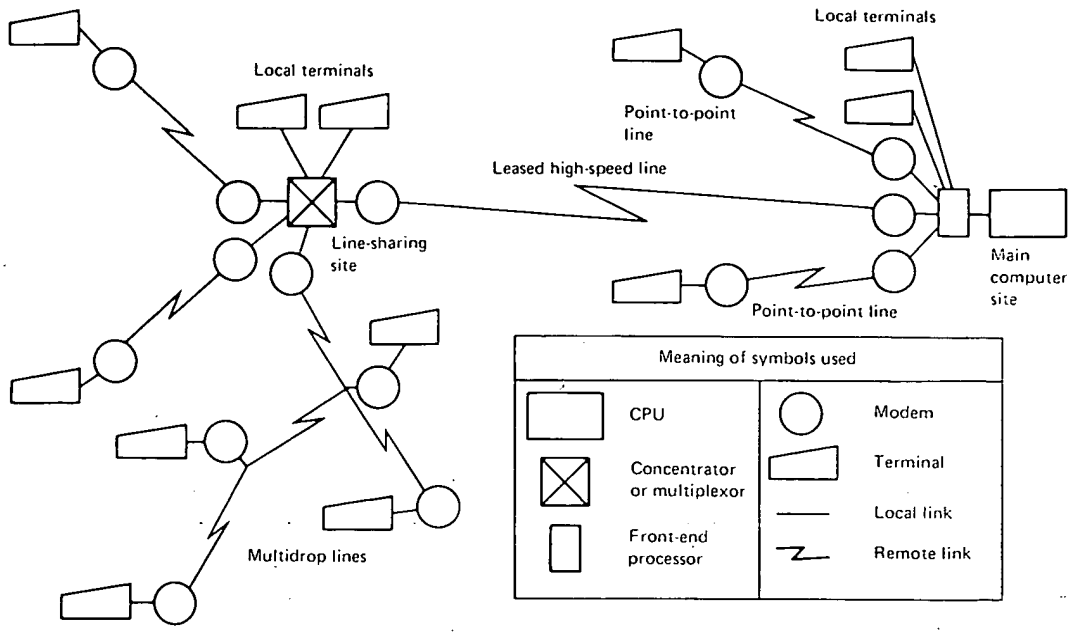


Figure 7.13
A data communications network.

Data Communications Carriers

Data communications carriers are organizations authorized by the Federal Communications Commission or state agencies to provide public communications services. Common carriers, such as AT&T, Western Union, MCI, and General Telephone and Electric, offer a wide range and variety of communications services. Specialized carriers sell high-speed voice and data communications services in selected high-density areas of the country. Value-added carriers lease communications facilities from the common carriers and combine messages from customers into groupings called packets, which are then transmitted. They offer specialized hardware, software, and data handling techniques that are not ordinarily available with traditional data communications services. In this way, they are able to "add value" to the transmission by improving transmission effectiveness and decreasing costs. Some firms are large enough, or localized enough, that they are able to establish their own private data communications networks.

Communications Networks

An information system may consist of a "stand-alone" computer that does not need to communicate with other computers. Most information systems, however, consist of one or more computers, a number of other hardware devices, and

communications channels linking the devices together to form a **communications network.** The network can take so many forms that most networks in use today are unique. This section of the chapter explains some of the more popular approaches to networks.

There are a large number of suppliers of data communications components, each with its own interface approach. The absence of interface standards has made it difficult for users to develop simple, unified data communications systems. It has also resulted in increased cost and complexity and reduced efficiency and effectiveness. To overcome this problem, manufacturers and computer organizations have banded together to develop standards. Their goal is to develop a **standard network architecture,** complete with standard protocols and standardized hardware, software, and communications channel interfaces.

Centralized Network

In a **centralized network,** data processing is done at a centralized processing center using sophisticated software. User terminals and other computers are linked to the host computer by point-to-point lines, multidrop lines, or multiplexed communications channels. Local terminals are usually connected directly, or "hard-wired," using coaxial cables. User interface may be by terminals, microcomputers emulating terminals, or various remote or local source data automation devices. Terminals may provide online, online real-time, or remote job entry (batch processing) access. Highly trained personnel operate and manage the system.

Varying degrees of complexity are possible in the basic hardware configuration. The simplest configuration is illustrated in Fig. 7.14. In this configuration several input/output terminals are linked directly to a central processor. A system of this type is called a **simplex system** because there is only one central processor. A simplex system cannot be available for use at all times because of preventive maintenance requirements and equipment malfunctions. Provisions for a manual backup system are thus necessary. The simplex system, however, offers the advantage of real-time capability at the lowest possible cost and with a minimum of complexity in hardware and software system design.

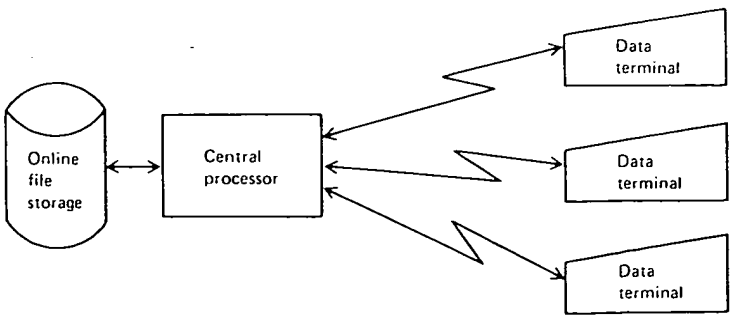


Figure 7.14
Simplex system.

Centralized configurations often utilize more than one CPU to maximize system availability and reliability. The **duplex system** illustrated in Fig. 7.15 uses two central processors. The second CPU takes over for the first during its scheduled maintenance or during an equipment failure. When the second computer is not substituting for the first, it generally performs batch processing or other jobs. The advantage of the duplex system is that it greatly increases system availability. Major disadvantages are increased system cost and the increased complexity of the software system required to switch operations from one computer to the other.

Centralized networks provide a number of significant advantages. Among them are economies of scale, better control, more experienced personnel, and elimination of duplicate functions. Among the significant disadvantages are greater complexity, higher communications costs, and less flexibility. The advantages and disadvantages of centralized processing are summarized in Fig. 7.16.

Distributed Data Processing Networks

A problem with centralized processing is that one system is trying to meet the requirements of a large number of users, many of whom have unique needs. The larger the system, the greater the likelihood that the users will feel the centralized system is not meeting their needs. The busier the system, the greater the likelihood that the system will be overloaded, making access difficult and slow. Some of these disadvantages can be overcome by implementing a **decentralized system**, in which there is an independent CPU and a data processing manager at each site. Decentralized systems, however, are lacking in such areas as communication between systems, amount of information available, and ability to control the various organizational entities.

An approach that achieves many of the advantages yet eliminates many of the disadvantages of both centralized and decentralized processing is known as distributed data processing (DDP). In a DDP system, data processing and data management tasks are distributed to the different company locations, which are connected electronically to form a DDP network. Each location has its own computer, its own storage and input/output devices, and often its own data. Each local

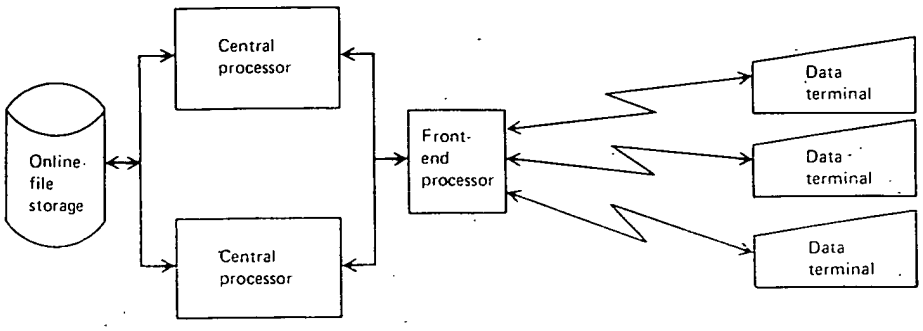


Figure 7.15
Duplex system.

Figure 7.16
Advantages and disadvantages of centralized processing.

Advantages of Centralized Processing

- ◇ Economies of scale may result from using a large mainframe rather than several smaller computers. Similar economies of scale apply to software and personnel costs.
- ◇ Processing is often easier to control because all significant processing is handled in one location.
- ◇ The more varied work experiences and greater career opportunities may make it easier to attract and retain more highly skilled technical, professional, and managerial personnel.
- ◇ Centralization of administrative functions such as billing, payroll, and purchasing may lead to cost savings and fewer coordination problems.
- ◇ It may be easier to develop and enforce standardized procedures and documentation, which facilitate communication, coordination, and control.
- ◇ It may be easier to structure, update, and control data, since the use of integrated data bases is facilitated. Also central processing may provide greater accessibility to data, which makes it easier to meet management needs.

Disadvantages of Centralized Processing

- ◇ Larger computers are usually more complex, and thus often require increased managerial supervision and better-trained and more experienced computer personnel.
- ◇ Centralized processing may involve higher communications costs than distributed processing.
- ◇ If there is only one central computer and it goes down, all processing stops.
- ◇ Centralized processing may not allow adequate or timely access to system resources if there are many users competing for time on the system.
- ◇ Operating systems are more costly and complex, requiring more system overhead.
- ◇ There is a greater tendency for the system to be rigid and inflexible. As a result, it is not as likely to meet a specific user's needs.

system is capable of processing its own data and thus has most of the advantages of decentralized processing. Because each local system is part of a network of interconnected processors, however, data can be transferred electronically between locations. Often, a large computer serves as the host computer, and local systems pass data to the host for summarizations and for preparation of top management reports. This setup gives the company many of the benefits of centralized processing. The result is a user-oriented (decentralized) as well as a top management-oriented (centralized) architecture.

DDP systems were introduced in the early 1970s, but their growth did not skyrocket until the microcomputer became a factor in the early 1980s. Since micros are as powerful as many of the mainframes of the early 1970s, they can handle much of the processing burden once borne by the centralized mainframes. Moreover, their processing power-to-cost ratio makes them a very attractive way to reduce the burden on centralized systems and spread the processing capabilities out to those who really need them—the users. As the power and capabilities of micros increase and as technological advances make data communications systems easier to use, the impact of DDP systems is bound to grow. A growth rate of 30 to 40 percent a year is forecast for the next decade.

There are a number of significant advantages to DDP systems. Computing power is placed in the hands of the user, and a great deal of flexibility is built

into the approach. Each local system can be treated as a module that can easily be added, upgraded, or deleted from the system. There are also a number of important disadvantages to a DDP system. The system may be more expensive than a centralized system. In addition, it is more difficult to coordinate the system and maintain hardware, software, and data consistency as each location tries to meet its own unique needs. The advantages and disadvantages of DDP systems as compared with centralized systems are summarized in Fig. 7.17.

DDP Systems Design. DDP systems can be organized in many different ways, and there are a number of system components that can be distributed. Systems designers can distribute the processing capability (the hardware and software) to each location. Some locations may have their own computers and software, others may only have data preparation and data entry equipment, and still others may have some intermediate processing capability. The data base can also be divided up and partitioned out to the individual locations. Alternatively, the data base can be stored at a central location and copies of the data needed by each location can be maintained locally. The partitioning approach avoids data redundancy but requires more complex data communications to permit other locations to find and access the data they need. The replication (or copy) approach has the advantage of a centralized data base, built-in backup files, and simpler data communications. It does, however, result in data redundancy. In practice, both approaches are used frequently, and large organizations often use a combination of approaches. That is, some data bases may be distributed, whereas others are not. In addition, some of the distributed data bases may use partitioning, whereas others use replication.

System functions can be distributed. One location may process receivables, another payables, another payroll. Although functional distribution works well in some organizations, it is not workable in many others. Control and authority can also be distributed. This is not the norm, however, as it makes it more difficult for the company to ensure that the data and security needs of the company are adequately met.

In designing and implementing a DDP system, there are several important factors to keep in mind. Since most DDP systems are complex, the system should be designed to ensure reliability. The more complex the system, the more things that can go wrong and therefore the greater the need for reliability. The system should be easy to use. The more difficult the system is to use, the less likely people are to use it. The system should be properly controlled to ensure data integrity and security. The system should be responsive to the user. If the system is slow and cumbersome, it will not be able to respond to users in a timely fashion and therefore will not be used. The system should also be flexible. It should be capable of handling a wide range of tasks and of efficiently meeting the varied needs of users. The system probably should not be installed unless it will pay for itself through cost savings or increased revenues.

Configurations. In a distributed network, there are several ways the network devices can be linked together. Figure 7.18 illustrates a **ring network,** in which the data communications channels form a loop, or a circular pattern, as they link

Figure 7.17
Advantages and disadvantages of DDP systems.

Advantages of DDP Systems

- ◇ Users have control over the local system, plus access to a more powerful system as needed.
- ◇ DDP often meets users' needs better than centralized systems, because processing is done at or closer to the local level. Users can tailor a system to their needs and improve the quality of the information generated.
- ◇ There is increased system availability and faster system response time.
- ◇ Network computers can provide backup for each other, and there is less risk of catastrophic loss since DP resources are in multiple locations.
- ◇ Smaller systems are often less complex and thus require less managerial supervision and less experienced and well-trained operators.
- ◇ Communications costs are often less, since most processing is done at local levels.
- ◇ The processing burden of the host computer is reduced.
- ◇ Local processing usually provides faster responses, since communication delays are eliminated, and there is usually less competition for system resources.
- ◇ Throughput can be increased by assigning tasks to specialized processors.
- ◇ Divisional managers are often more motivated to seek out profitable computer applications and participate in their development.
- ◇ Optimal usage of system resources occurs. For example, a smaller system can call on centralized systems (or the computer in the network) if a job is too large or if it is temporarily overloaded. The work load can be better balanced, and peaks in processing can be smoothed out.
- ◇ Processing locations can easily be added, upgraded, or deleted from the network as needed.
- ◇ During peak processing times, processing tasks can be forwarded to other systems in the network.

Disadvantages of DDP Systems

- ◇ There may be significant data duplication owing to multiple locations, each with a data base.
- ◇ Hardware costs may be higher owing to the resources needed at each location.
- ◇ It may be more difficult to standardize documentation and control, since authority and responsibility are also distributed.
- ◇ Multiple locations and communications channels make it harder to have adequate security controls. Also, the relatively unsophisticated operating systems of smaller computers in the network make the introduction of elaborate security features and controls difficult.
- ◇ Localized processing can make separation of duties more difficult.
- ◇ There is less on-site expertise, since the expertise possible with a centralized system cannot be duplicated at each site.
- ◇ Local computers usually do not have the capacity, power, or sophistication of a centralized computer.
- ◇ It may be difficult to maintain hardware, software, and data consistency as locations meet their specific needs.
- ◇ It may be more difficult to transfer data between system components.
- ◇ Difficulties in controlling hardware acquisitions may result in the purchase of incompatible equipment.

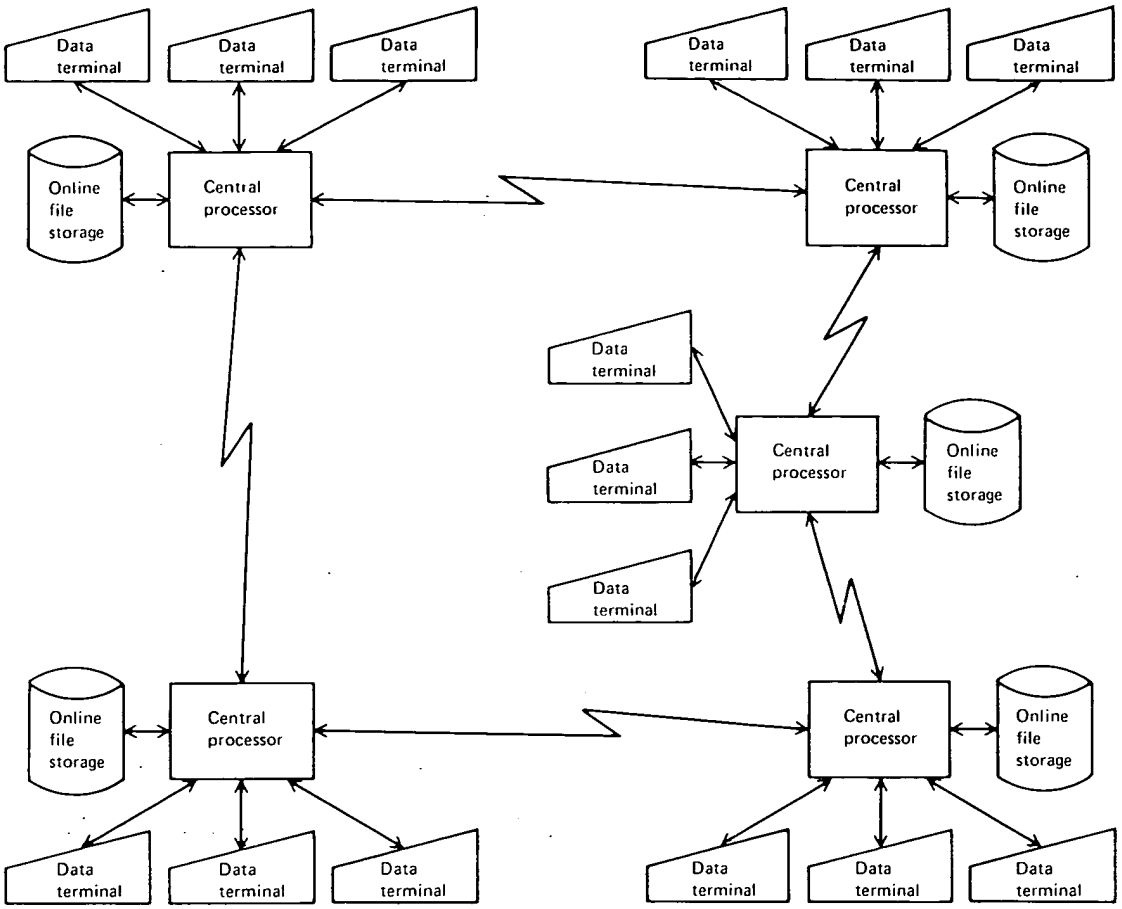


Figure 7.18
A distributed processing network—the ring configuration.

the local processors together. Each computer communicates with its neighbor and passes any message not intended for it around the ring to the appropriate computer. Communications processors are often used to handle communications activities at each location.

At the opposite extreme is the **star network,** which is illustrated in Fig. 7.19. In a star network, there is a real-time central computer system to which all other computer systems in the network are linked. Each distributed computer routes all data and messages through the central computer, which forwards them to the proper location (this process is called **network switching**). A star network has the same configuration as a point-to-point centralized processing system. Thus a centralized system can be changed to a DDP system by substituting microcomputers or minicomputers for the remote terminals and shifting some of the processing to the micros or minis.

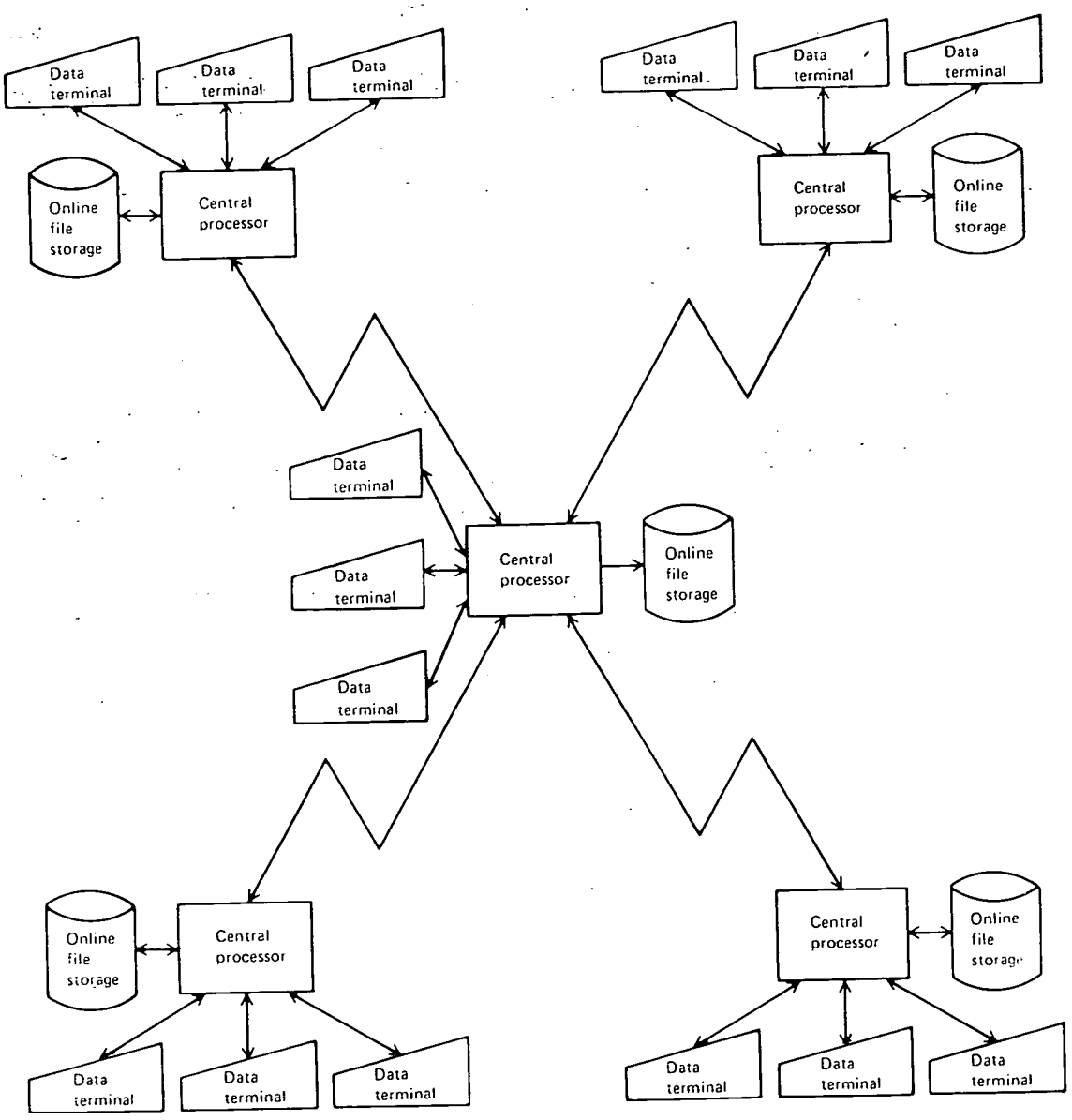


Figure 7.19
A distributed processing network—the star configuration.

Between these two extremes are **hybrid networks** containing both ring and star patterns. For example, several large systems might be linked together in a ring configuration while each also serves as the center of a star configuration consisting of smaller systems. A **hierarchical network** is a variation of the star network. It is so named because it looks and acts like a hierarchical organization

chart. It consists of several levels of computers, all tied to a central or host computer. For example, a company might have a large computer to service the central office and top management needs. It might be connected to medium-sized computers at each regional office, each of which in turn is linked to small computers in each branch location. Each level processes its own data and passes upward the summary data needed at the higher level. In addition, any job that is too large to be handled at the current level is passed upward. Data are likewise transferred from the top level down to lower levels. Figure 7.20 is an illustration of a hierarchical network.

The ring configuration allows "adjacent" computers to communicate directly. However, a message sent to a nonadjacent computer has to pass through one or more other computers in the ring. If there is much communication within the system, each distributed system may need sophisticated control hardware and software. Many systems requiring a lot of internal communication use a star network so that only one set of hardware and software is needed to route messages. A star network, however, is less reliable, since all messages must go through one unit. If the central computer goes down, the entire system goes down. In a ring network, there is an alternative route (around the ring in the other direction) if one of the computers or communications channels goes down.

Because of these conflicting factors, there is no simple answer to the question of which approach is best. That decision is usually based on the distance between the points in the network, the amount of data to be transmitted, how quickly the message must be communicated, and the ability of each location in the network to handle messages. The decision also depends on the organization's needs and the specific circumstances of the situation. In practice, most organizations use some combination of approaches.

Local Area Networks

Many organizations would like to improve their communications systems by allowing computers located in the same geographical area to communicate with each other and to share hardware devices. This type of linkage reduces the investment required in hardware and software, since everyone, for instance, does not have to have a high-quality printer or a separate copy of a software package. It also allows users to conduct many of their communications tasks electronically. A **local area network** (LAN) can be used to link together microcomputers, word processors, disk drives, printers, modems, computer terminals, and a variety of other office and data processing equipment located in a limited geographical area, such as a building.

LANs are composed of six major components. The first is the hardware, such as micros, printers, and disk drives. The second is the wiring, or the cable that connects the hardware. In a cable LAN, electronic cable is used to connect the network devices. If the cable is very long, electronic devices are used to boost signals so that they remain strong and clear. In newer buildings this cable is installed during construction, so hardware devices can be plugged into the cable in

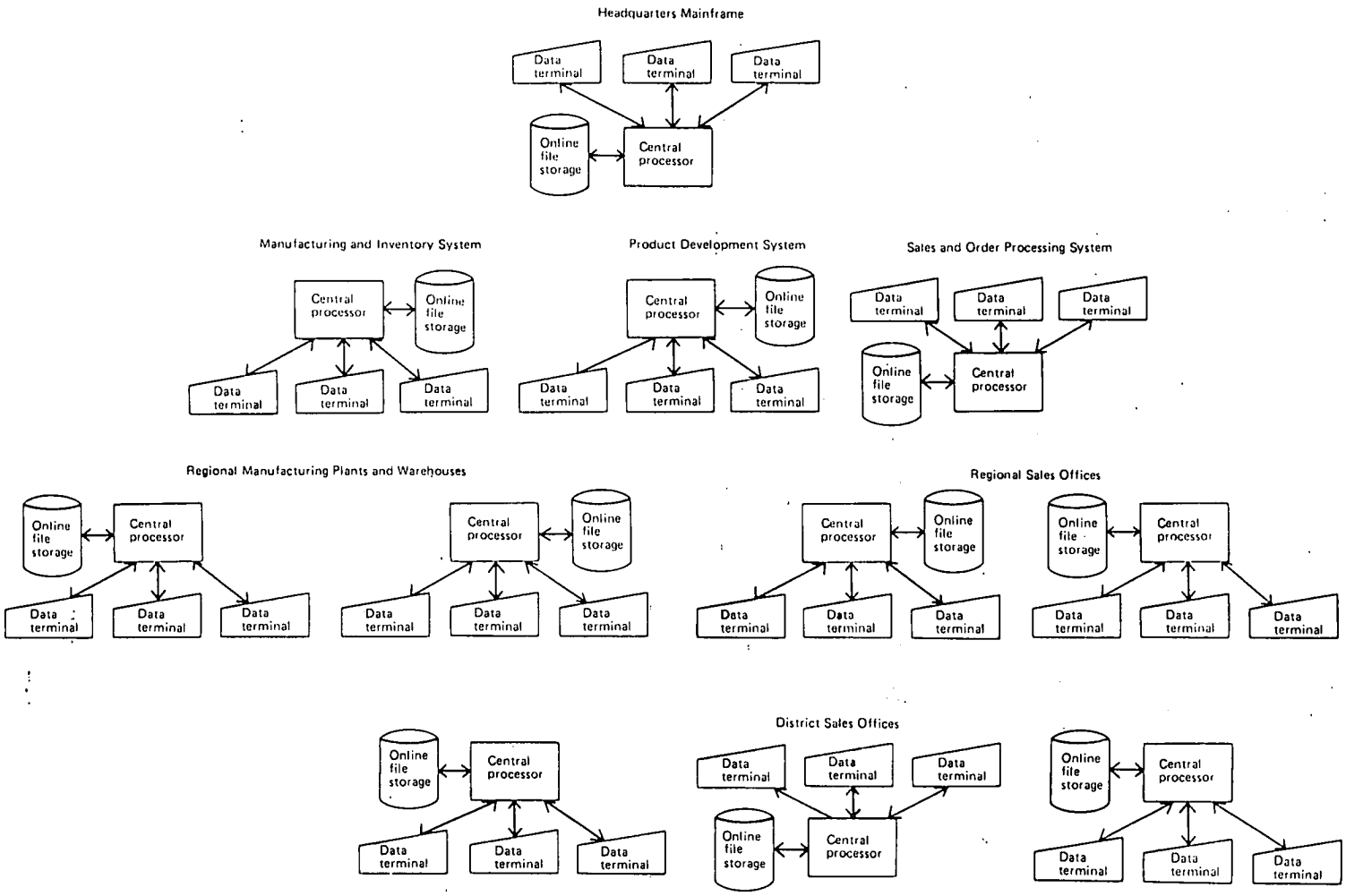
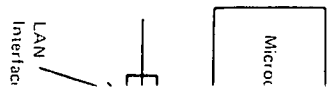


Figure 7.20
Hierarchically distributed processing network.



the wall, just as telephones are now hooked up. As a result, these new buildings have electrical outlets, telephone outlets, and data (or information) outlets.

A third component is the LAN interface. Each hardware device that is to be connected to the network cable needs an interface device that manages the attachment and transmission process. A fourth component is the network master controller, which is the brain of the LAN. The master controller is a software program which serves as the intelligence of the LAN and acts as a traffic manager to route data between the hardware and to prevent and detect data "collisions." A fifth component is the network server. It is usually a hard disk drive containing the software (or protocols) that run the LAN and the programs that are available to network users. A sixth component is a communications interface device called a gateway. The gateway allows the LAN to be connected to external or wide-area networks and to communicate with external mainframes and data bases. The gateway allows the network devices to communicate with computers almost anywhere in the world and to draw on the greater computing power and storage capacity of larger systems. An example LAN configuration is shown in Fig. 7.21. A LAN can also be configured as a ring or star network like larger systems discussed earlier.

When a device is ready to send a message over the LAN, it breaks the message down into packets of data. Each packet usually contains 1024 characters of data. Each packet is assigned a code that identifies the sending and the destination location. The sending station then "listens" to the line, and when it is free the

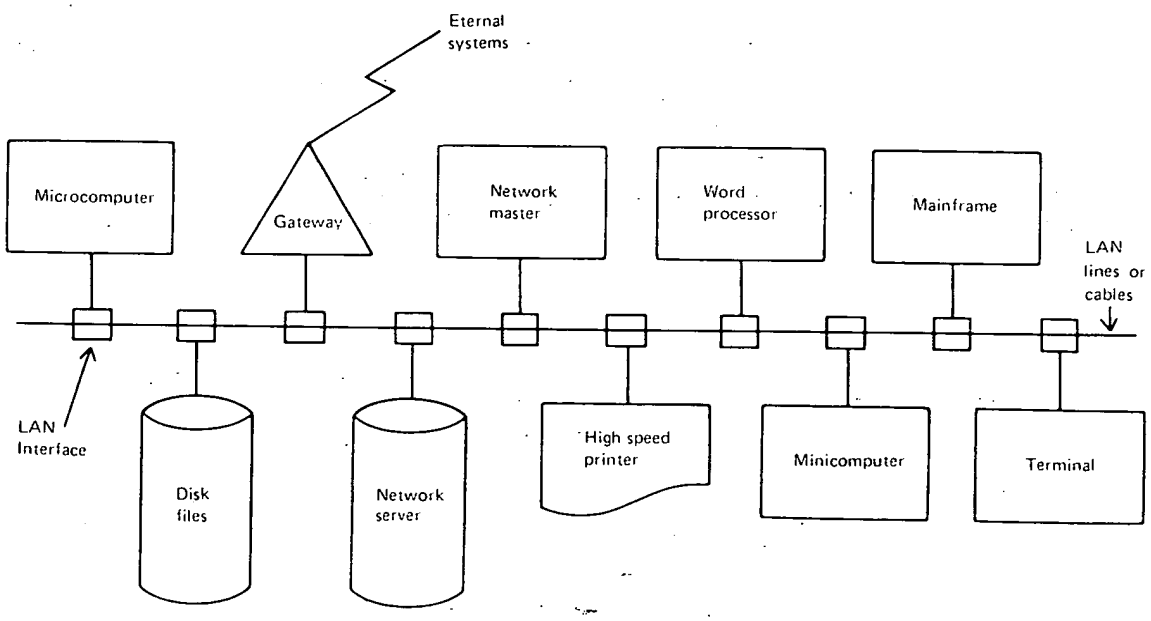


Figure 7.21
Local area network configuration.

Figure 7.20
Hierarchically distributed processing network.

message is placed on the line. The message is carried along the LAN line to its destination. Each station listens for packets addressed to it and removes them as they arrive. When transmission has been completed and the message has been removed from the line, the receiving station sends an acknowledgment back to the sending station. Data transmission in a LAN is very fast—up to ten million bits (500 pages of text) per second.

A number of companies have developed LAN systems. The most popular are NetWare (Novell), Ethernet (Xerox Corporation), 3Com (3Com), and Vines (Banyan).

Most LAN systems are quite flexible. Hardware devices can easily be added and deleted, and breakdowns in particular devices have no effect on other system devices. They offer enormous potential for improving communication in organizations. The major deterrents to the system are the lack of quality software for the LAN systems and the lack of protocol standards. As better software is developed and as protocols are standardized, LAN systems will become a major force in bringing to pass the automated office of the future.

Public Data Networks

Most organizations cannot afford to have their own private data communications systems gather and maintain all the data they need to make decisions. Public data networks provide a viable alternative for these organizations. These networks are large, privately owned organizations that sell computing services and information to the public for a fee.

One service that public data networks make available is **time-sharing.** A time-sharing system sells users small slices of time on large mainframes. A company can rent hardware time, software programs, or both. Users can send data to the service electronically, have it processed, and then have it returned to them. Public data networks also can be used for teleconferencing, electronic mail, sending and retrieving messages, and electronic funds transfer (EFT). Public data networks can be used for sending high-resolution graphics and for generating voice responses. The services can also be used to share a centralized data base with remote users or connect otherwise incompatible machines together.

One of the most important services offered is access to public data bases. These public data bases are electronic libraries containing millions of items of data that can be reviewed, retrieved, analyzed, and saved. They may contain anything that a publisher or other provider of information wants to make available to the public. The information can be supplied by the company setting up these data base retrieval systems (DBRSs) or by independent authors who are paid a royalty each time the information they supply is accessed. Almost any information that a user might need is available, including some that is not even in print. As a result, "electronic libraries" have begun to replace regular libraries among those who know how to use the DBRS and can afford the cost. Over 300 vendors supply more than 2000 data bases to over thirty million people, who spend over $3 million to access the data bases. Some of the most popular data bases are Dow Jones News/Retrieval, CompuServe, The Source, Quotron, TRW

Inc., and Mead Data Central. These services are the most popular because they are the most comprehensive.

All that is needed to access these data bases is a personal computer or a terminal, a modem, communications software, a telephone, and an account with the DBRS vendor. The communications software is loaded into the PC, and the vendor's telephone number is dialed. The communications software helps the two devices communicate, and the vendor's software sends a menu to the computer. Using a series of menus, the user selects the desired service and identifies the tasks to be performed and any criteria the software needs to perform the task. When the task is finished, the communications software logs the user off the system. Search costs run from $5 to $200 an hour and vary depending on the time of day. In addition to the search charge, there are communications network charges and local telephone charges. A typical data base search takes from eight to eighteen minutes and, depending on the data base searched, costs between $5 and $20.

The major advantage of such a system is obvious: instant access to a large amount of data. The main disadvantage is the difficulty of learning how to access the different DBRS services and how to search them effectively. The costs of the searches are reasonable given the information retrieved. It would often take hours of painstaking research to find the same information in a nonelectronic library.

Videotex, a new class of service, has become available in the last few years. Videotex services use a telephone, a television, and a special decoder. Modems and personal computers are not required. Using videotex, the user can access data bases and retrieve both text and graphic images. Users pay a fee for each page or screen of data accessed. Among the potential applications are electronic shopping, electronic banking, and electronic newspaper delivery. Shoppers of the future, for example, may be able to see models displaying the latest lines of clothing while someone extols the virtues of particular items either by voice or printed text.

Data Communications Applications

Although data communications systems are generally more costly and complex than conventional data processing systems, their utilization has increased sharply in recent years. This increase reflects their high potential as a profitable management tool. This section discusses just a few of the many uses for data communications systems in today's businesses.

Computer-based Message Systems

Data communications systems are used to transmit electronically a wide variety of items, including documents, memos, pictures, graphics, mail, and voice messages. A number of word processing systems are configured in such a way that they can communicate directly with other word processing systems. As a result, documents can be forwarded easily between the connecting word processing sys-

tems. **Facsimile transmission** (sometimes called FAX) allows not only documents but also pictures, graphics, and signatures to be sent over a data communications system. A facsimile machine at the sending station translates the different shades of light and dark on a page into signals that can be sent over the communications links. A similar machine on the receiving end translates the signals back into the proper images and reproduces them on a piece of paper. Recently the price of FAX technology has sharply decreased while performance has increased. Hence, the use of FAX technology is fast becoming commonplace.

Electronic mail systems allow a person to send, receive, or forward a message to or from anyone else who has a "mailbox," or electronic storage location, in the system. In many systems, the sender can include files, such as spreadsheet worksheets or reports, with the message. The system can be used to send messages internally or to units external to the organization. These systems can at least partially replace the telephone and the regular mail system. By setting up predefined distribution lists, users can avoid having to reenter names each time a message is sent to the same group.

Voice mail, or a voice store-and-forward system is a flexible system that can be used to send a spoken message to someone even when the person is not at his or her remote terminal (telephone). These systems convert a spoken message into a computer-storable digital message that is stored in the receiver's electronic mailbox. Voice mail can be distributed in the same way as text messages are except that hard (printed) copies cannot be produced.

Teleconferencing is another means of communicating electronically. AT&T, for example, has set up teleconferencing rooms where conferees can gather and use closed-circuit TV to conduct a conference with multiple users at multiple locations. Personal computers are also being used for teleconferencing. All communication must be written on the terminal screen, but multiple users in different locations can be linked together. The use of teleconferencing is growing rapidly. For example, IBM has developed its own teleconferencing network on which a majority of its corporate training takes place. The system paid for itself in travel savings in the first six months of use.

Computer-based transmission of messages has a number of important advantages. Messages can be distributed very quickly, and the sender does not have to worry about busy signals or unanswered phones. In addition, since most systems are capable of informing the sender that the message was placed in the receiver's mailbox, the sender has fewer worries about whether a message was received. The cost of communication is quite reasonable. A further advantage is that the user and the receiver can send or read their mail at any time simply by accessing the system.

These computer-based message systems are the foundation of the widely heralded **automated office,** or office of the future. In these offices, all workers are connected electronically and pass messages, files, worksheets, and other information to each other over the LAN that connects their **multifunction workstations.** These workstations are usually high-powered microcomputers that share common resources and are capable of both data and word processing.

Transportation and Travel Reservations

Firms in the travel industry, notably the airlines and major motel chains, were among the first to implement data communications systems, to process and confirm customer reservations. Data terminals or microcomputers are located at each reservations counter or motel lobby. Online file storage devices contain a record of the availability of services, such as seats on airline flights or rooms at motels in a chain. A customer may request a reservation in person or by phone. The reservation is entered into the system, and if the requested seat, room, or other service is available, the file record is updated and the reservation is immediately confirmed to the customer.

In an airline reservations system, several functions may be performed in addition to maintaining records of seat availability and processing reservations. These include calculating fares, updating sales and accounts receivable records, responding to customer requests for reconfirmation, and processing passenger check-ins. In a motel room reservations system, functions such as calculation of room charges, guest check-in and check-out, and revenue accounting are generally performed at each local unit rather than by the data communications system.

Banking Systems

Banks were also among the first institutions to use data communications systems. In a banking system, various customer functions are performed at teller windows and automated teller machines (ATMs). A primary function is checking a customer's account to determine whether the balance is large enough to cover a withdrawal being made by the waiting customer. In addition, deposits and withdrawals may be posted to customer accounts through the system. Hardware requirements include a data terminal for each teller window, ATMs at various locations, and online file storage to maintain a record of each customer's account.

The banking system makes an up-to-date record of each customer's account available to every teller and ATM, even those located at a distance from the main bank. Such systems enable banks to provide faster and more convenient service to customers, while reducing the number of tellers required to wait on customers.

Many banks have since expanded their applications into other areas, such as mortgages, commercial loans, consumer loans, and credit files. In recent years the concept of having one gigantic data communications system to handle all banking transactions has emerged. Retail merchants would be tied into the banking network through point-of-sale terminals and microcomputers, and sales transactions would be immediately charged to the consumer's bank account and simultaneously credited to the merchant's account. Transactions among corporations and other institutions would be handled electronically rather than by check. Deposit of paychecks to the bank accounts of employees by their employers would also be done electronically. Using microcomputers and modems,

individuals could access the bank's system and pay all their bills electronically. This concept has become known as **electronic funds transfer** (EFT).

The ATM provides bank customers with banking services twenty-four hours a day. All they have to do is find an ATM, insert their specially coded plastic bankcard, and type in a PIN (personal identification number). The PIN is a confidential code known only to the bank's customer and the computer. Using the bank's data communications network, the ATM checks the PIN to see whether it matches the account number on the bankcard. If it does, the user can withdraw or deposit funds. With the proper ATM and data communications links, the user can also purchase a variety of other items, such as stamps, airline tickets, and movie and play tickets.

Retail Sales

Many retail organizations utilize data communications systems to collect and summarize sales data and to perform credit checking and inventory control functions. Electronic cash registers and point-of-sale recorders serve as data terminals for these applications. They capture, at the point of sale, such information as the item sold, the quantity, and the price. In such applications a customer's credit standing may be checked at the time a credit transaction is initiated. The credit is checked by forwarding the credit card number to the bank's computer, which electronically determines the credit standing and amount of credit that can be granted. If the credit sale is authorized or if the sale is for cash, the inventory file is accessed and updated for the specific merchandise sold. In addition to maintaining an up-to-date record of all inventory items, the system can originate inventory reordering as needed. Up-to-date sales and inventory totals can be obtained by management through online data base queries. The system also can maintain the price of the item purchased and automatically ring up the amount. Many systems use audio response units to inform the customer of the amount.

Sales Order Processing

A sales order processing system is similar in many respects to a retail sales system. Many companies could gain a significant competitive advantage by using a data communications system to shorten the time between the receipt of customer orders and their delivery. Such a system could maintain a finished goods inventory file online and could have data terminals or microcomputers distributed throughout the sales territory. Salespeople could call orders in to a regional center at which the terminals or computers were located, or, alternatively, each salesperson might be equipped with a small portable terminal or computer with which he or she could enter orders directly from the customer's plant or office. The system would access the finished goods inventory file to confirm the availability and quantity of each item ordered, and this information would be relayed to the salesperson immediately. The finished goods inventory file would be updated as the orders were placed. All appropriate journal entries would be made immediately

in the general ledger, and the invoice could be immediately posted to an online accounts receivable ledger. If inventories were stored in a network of warehouses, delivery could be initiated by electronically transmitting a shipping order to the warehouse closest to the point of delivery.

In addition to speeding up the sales-order delivery cycle, the system could also have several other useful features. With the accounts receivable file online, a salesperson could answer customer inquiries about the status of the customer's account. The credit checking process also could be accomplished online as part of the order entry process. In addition, a sales analysis master file could be updated as orders were placed. This file could be used by marketing executives to generate up-to-date information on sales trends, thus facilitating management control of the sales function. Furthermore, as the finished goods inventory balances were updated, the updated balance of each item could be checked to determine whether reordering or additional production was necessary to replenish the stock.

The significance of such a system lies not only in the confirmation of sales orders in real time, but also the complete integration of the accounting function. One entry of data would result in the updating of all accounting records affected by the data and initiate the preparation of all documents necessary for processing the transaction. A more extensive discussion of such a system is provided in Chapter 16; in particular, see the systems flowchart in Fig. 16.9. Electronic data interchange, discussed in the following section, takes sales order processing one step further—customers enter their own orders.

Electronic Data Interchange

Imagine you are a manager in an organization currently struggling with three problems regarding the processing of transactions with both suppliers and customers. First, the current manual system is very slow, often requiring one to two weeks to complete a transaction agreed on over the telephone in a matter of minutes. Second, because the processing of transactions involves a number of people, the cost of processing each transaction is rather high. Third, clerical errors on the part of the people processing the transactions are common and result in even longer processing time, strained relations with both suppliers and customers, delayed production, and so forth.

One potential solution to these problems is the use of Electronic Data Interchange (EDI). EDI is fast becoming the standard means of processing transactions between organizations in a number of industries. Rather than exchange physical copies of purchase orders, invoices, or bills of lading, the participants transmit the information on these documents electronically. The flow of transaction data, with and without EDI, is illustrated in Fig. 7.22. EDI is characterized by three features:

1. *Electronic transmission of business transaction documents.* The core of EDI is the elimination of paper flow between two organizations. Transaction

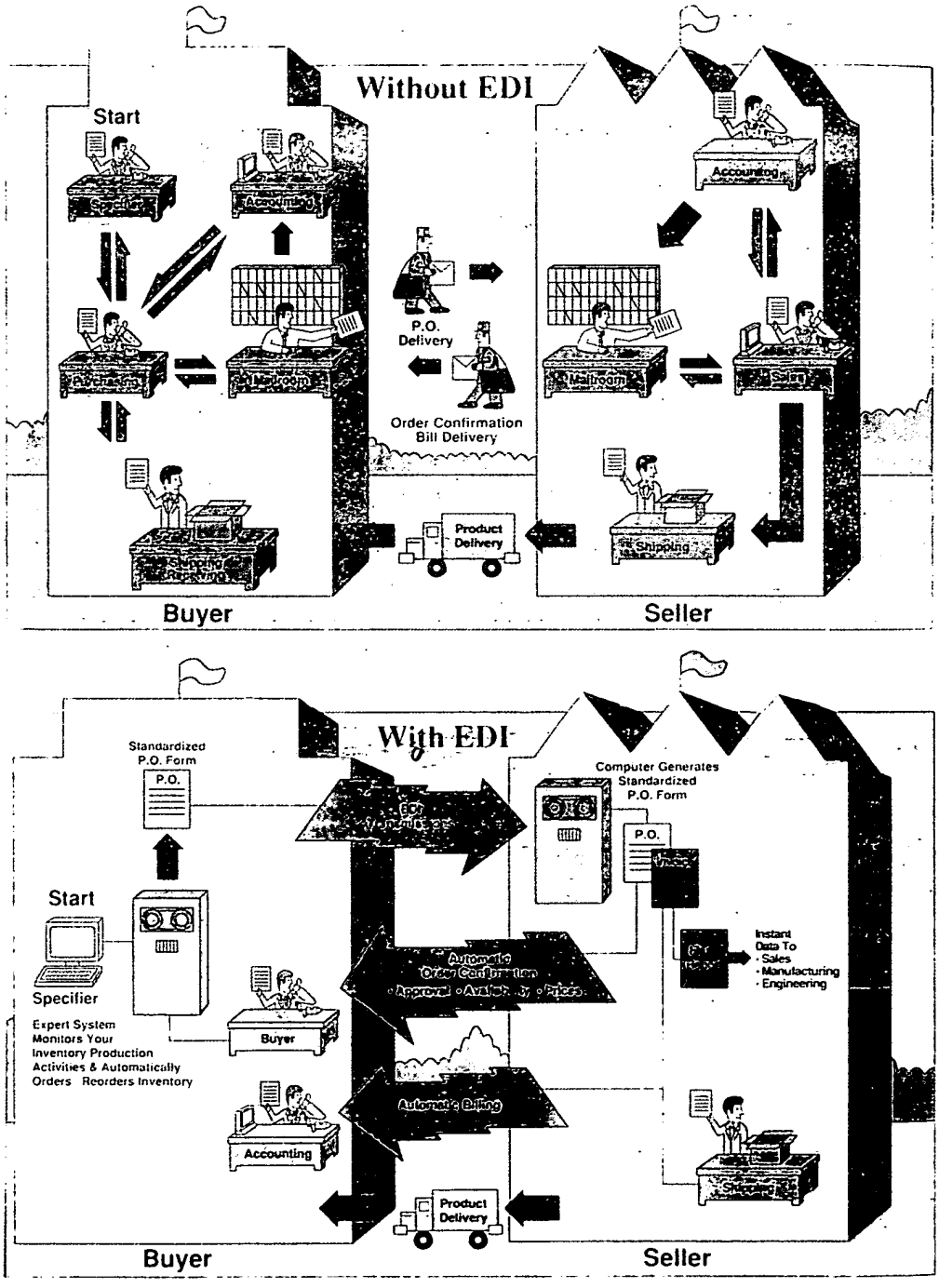


Figure 7.22

Transaction data exchange with and without EDI. (Willie Schatz, "EDI: Putting the Muscle in Commerce and Industry," Datamation, *March 16, 1988, pp. 56-64.) Reprinted with permission.*

information is sent via communication lines, rather than physical documents.

2. *Computer to computer exchange.* Because the information is in electronic form, human intervention is limited to transaction verification, rather than processing. As a result, the speed of the process is greatly enhanced and the likelihood of clerical error greatly reduced.
3. *Hardware independent standardized formats.* To facilitate and ensure the proper processing of transactions, standards are established that allow two organizations to exchange transaction data electronically.

Currently EDI technology is having a tremendous impact on a number of businesses, and it is expected to spread to every major industry. Link Resources Corp., of New York, estimates that the number of companies using EDI will jump from 3,500 in 1988 to over 10,500 by 1991. EDI is beginning to become a major means of executing transactions not only domestically but also internationally. Some sources estimate the percentage of transactions processed using EDI to be 90 percent for the railroad industry, 75 percent for the trucking industry, 50 percent for the grocery industry, and 35 percent for the auto industry. The pressure to adopt EDI can come from management's own desire to reduce processing time and costs, from a supplier's offer to provide additional discounts if EDI is used, or from customers' insistence that they will do business only with those who use EDI.

EDI is not without its problems. Issues such as standardization of product and service codes, transmission protocols, and security of data are all significant and are being studied in earnest. It appears that the benefits of EDI far outweigh the problems, however. Given the ability of EDI to address significant problems businesses face in processing transactions with other organizations, its use can only be expected to increase.

Summary

A data communications system consists of five major components: the sending device, the communications interface device, the communications channel, the receiving device, and communications software. Signals in a data communications system may be analog or digital; serial or parallel; asynchronous or synchronous; simple, half-duplex, or full-duplex.

There are a number of hardware devices that can be attached to a communications channel and used to send data to or receive data from a computer. These include dumb and intelligent terminals; micro-, mini-, and mainframe computers; and source data automation devices. Communications interface devices, such as multiplexors, concentrators, and front-end processors, make it possible for slow-speed data communications devices to take advantage of high-speed transmission lines.

Data communications systems software is usually more complex than conventional systems software. Special communications control programs manage the data communications activity and interact with the various terminals. The control

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programs may be executed either by the main computer or by a programmable front-end processor.

A communications channel connects the sender and receiver in a data communications network. This connection can be accomplished with a coaxial cable, a standard telephone line, or a fiber optics cable or with terrestrial microwave systems, satellite, or cellular radio. Communications channels are classified according to their information carrying capacity: narrowband, voiceband, and wideband. Three voice-grade telephone line services are available: leased lines, switched lines, and WATS lines. Communications channels may be configured in three basic ways: point-to-point, multidrop, and line-sharing. Communications channels link a variety of hardware devices together to form a communications network. The networks can take one of the following forms: centralized, decentralized, distributed data processing, local area, and public data.

A wide variety of data communications systems are being used in computer-based message systems, transportation and travel reservations, banking, retail sales, sales order processing, and electronic data interchange. EDI is fast becoming a common means by which businesses exchange transaction data.

REVIEW QUESTIONS

1. Define the following:

telecommunications systems
data communications
centralized data processing system
teleprocessing systems
distributed data processing
message
bits per second
digital
analog
serial transmission
parallel transmission
asynchronous transmission
synchronous transmission
simplex channel
half-duplex channel
full-duplex channel
terminal emulator
multiplexor
concentrator
front-end or communications processor
communications control programs
micro-to-mainframe link
protocol
communications channel
coaxial cable
fiber optics cable
terrestrial microwave
satellite microwave
cellular radio
narrowband lines
voiceband lines
wideband (or broadband) lines
leased lines
switched lines
Wide Area Telephone Service (WATS) lines
point-to-point lines
multidrop lines
line-sharing device
polling approach
contention approach
communications network
standard network architecture
centralized network
simplex system
duplex system
decentralized system
ring network
star network
network switching
hybrid network
hierarchical network
local area network
time-sharing
videotex
facsimile transmission
electronic mail systems
voice mail
teleconferencing
automated office
multifunctional workstation
electronic funds transfer
electronic data interchange

Chapter 8

Data Base and File-Oriented Systems

Learning Objectives

After studying this chapter, you should be able to:

- ◇ Explain and define fundamental data storage concepts.
- ◇ Compare and contrast the file-oriented and data base approaches to data storage.
- ◇ Explain the difference between the logical and physical views of data.
- ◇ Explain what a data base management system (DBMS) is, what it does, and what it is composed of.
- ◇ Compare and contrast DBMS functions and users.
- ◇ Compare and contrast various file and data base organization and access methods.
- ◇ Explain the role of accountants in data base design.
- ◇ Explain the impact of data base systems on accounting.

Chapter Outline

An accounting information system is designed to produce information for a wide variety of users. These users need information for record keeping, planning and evaluation, and decision making. To produce this information, an organization must process and store records of the events, activities, and transactions that occur. Thus the management and storage of data is one of the most critical functions of an accounting information system.

Accountants have a significant role to play in the data management and storage process. For example, they must interact with systems analysts to help the organization answer questions such as the following. What data should be stored by the organization and who should have access to them? Which data storage approach should be used: manual, file-based, or data base? How should the data be organized, updated, stored, accessed, and retrieved? How can both scheduled and unanticipated information needs be met?

To answer these questions and others like them, accountants must understand the data management and storage concepts explained in this chapter. The first section of this chapter discusses data storage concepts and the file and data base approaches to data storage. The second section examines the differences between the way users view data and the way they are actually stored in the computer. The third section looks at the software that makes the data base approach possible and the people who typically use data base systems. The next two sections explore file and data base organization and access methods. Finally, the last two sections discuss the role of accountants in data base design and the potential impact of data base systems on accounting.

The File and Data Base Approaches to Data Storage

There are certain fundamental concepts and definitions that must be mastered in order to understand how data are stored and retrieved. These concepts, as well as the file and data base approaches to storing data, are discussed in this section.

Fundamental Data Storage Concepts and Definitions

Imagine how hard it would be to read a textbook if it were not organized into chapters, sections, paragraphs, and sentences. Also imagine how hard it would be for an organization to find anything if its data were randomly dumped into file cabinets. Fortunately, most books and company files are organized in such a way that information can be retrieved easily. Likewise, EDP systems can be organized such that data can be stored and retrieved efficiently. This section reviews and expands the basic data storage concepts and definitions introduced in Chapter 3 using accounts receivable information as an example.

As explained in Chapter 3, an entity is an item about which information is stored. Each entity has attributes, or characteristics of interest, that need to be stored. For the various entities, each attribute has a data value. For example, P.O. Box 7 is the data value of the address (the attribute) for XYZ Company

(the entity). A **relationship** is a correspondence, or association, between entities, such as a customer and a sales transaction.

Data in EDP systems are stored by organizing smaller units of data into larger and more meaningful units of data. This data hierarchy, beginning with characters (the smallest element) and ending with data bases (the largest), is shown in Fig. 8.1. A **character** is a number or letter and is the smallest element of data that is meaningful to a user. Characters are combined to form **data values** (such as P.O. Box 7). Data values are stored in fields, which are grouped together to form records. Thus a record is a collection of data values that describes specified attributes of an entity. In Fig. 8.2, for example, each row represents a different record, and each column represents an attribute. The intersection of each row and column is a field. Each field contains a data value that describes the particular attribute and the record to which it pertains.

A field may be characterized by its format—that is, the type of data stored in it. A numeric field contains only numeric data, such as a dollar amount. Fields that can contain only alphabetic data, such as a name, are called alphabetic fields. Alphanumeric fields contain both alphabetic and numeric characters, such as street addresses or inventory item descriptions. Monetary fields contain data such as wage rates and account balances. The characters stored in a data field are always interpreted by the system to represent a specific month, day, year, or some combination thereof.

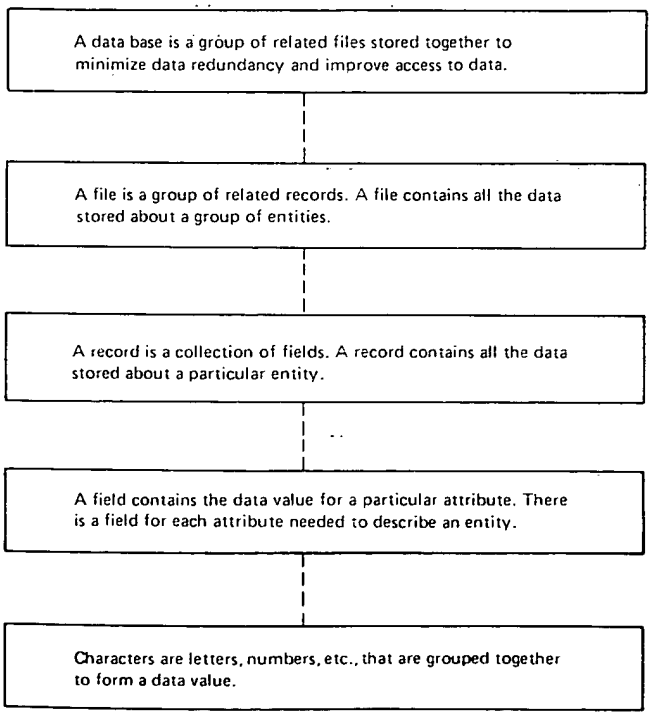
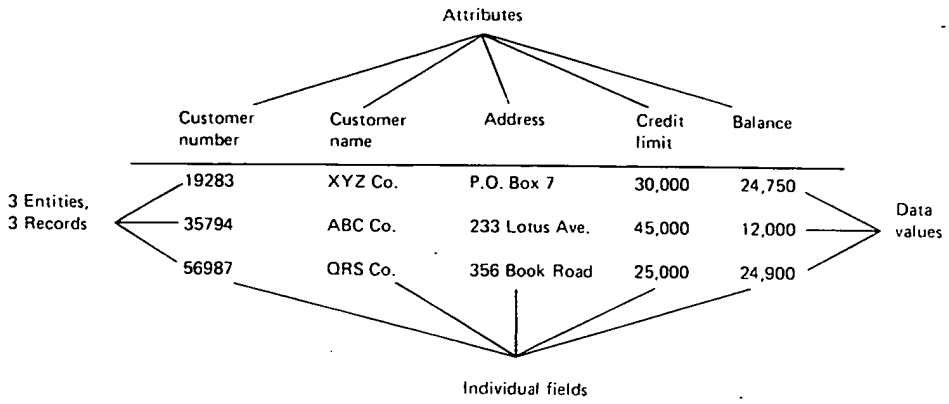


Figure 8.1
Hierarchy of data elements.



This accounts receivable file stores information about three separate entities: XYZ Co., ABC Co., and QRS Co. As a result, there are three records in the file. Five separate attributes are used to describe each customer: customer number, customer name, address, credit limit, and balance. There are, therefore, five separate fields in each record. Each field contains a data value that describes an attribute for a particular entity (customer). For example, the data value 19283 is the customer number for the XYZ Co.

Figure 8.2
Accounts receivable file.

A record is similar in concept to an individual folder in a manual file. In a manual system, all the information about a particular customer may be stored in an individual file folder. Likewise, in an EDP system all the data about a customer are stored in a record. Records can be of fixed or variable length. **Fixed-length records** contain the same number of fields in each record and are used when each record is to contain the same number of fields. **Variable-length records** differ in length and are used when the number of fields to be stored per record differs. Suppose, for example, that the invoice numbers of the sales documents that make up the receivables balance are to be stored in the accounts receivable record. There may be one or dozens of invoices that make up the balance. Using variable-length records to store the invoice numbers is more space-efficient than designing fixed-length records that contain fields for all possible invoice numbers (assuming that the maximum number could be identified).

Similar records are grouped together to form a **file** (or data set). For example, all receivable records are stored together in an accounts receivable file. The different types of files used in business organizations are described in Chapter 3. In recent years, files containing related data have been combined to form what are called data bases. For example, the accounts receivable file might be combined with the customer, sales analysis, and other similar files to form a customer data base. The two alternative approaches to computer-based data management are based on using files and using data bases. The use of files as the primary structure for storing data is referred to by a variety of names, including the **file-oriented approach,** the traditional approach, and the application approach. The

use of data bases as the primary data storage structure is referred to as the **data base approach** or the data base management system approach.

Figure 8..
Disadvanta
the file-ori
approach.

The File-Oriented Approach

Organizations that have used computers in data processing for a number of years have typically experienced a proliferation of computer applications. Accompanying this proliferation has been a growth in the number of computer files required to support the data storage needs of new applications.

Many companies have developed their information systems on a piecemeal basis by adding new applications as the need arises. These new application programs have been designed to meet the specialized needs of a limited number of users. The end result is an approach that is focused on the individual application. The data needed for each of these independent applications are organized, processed, and stored in one or more independent master files. The set of data thus stored "belongs" to, and is managed by, the department or organizational entity that created it, and each set of files is independent of every other set.

Problems arise, however, when users need information contained in two or more files. If an existing application program cannot provide the information needed, satisfying the information request can be very costly and time-consuming. The inability of the system to meet even the simplest requests for information in such situations can be frustrating to management and other users. Additional problems of the file-oriented approach are data redundancy, data inconsistencies, and inefficiencies due to the large number of data files that must be updated and processed. Figure 8.3 contains a more complete explanation of the disadvantages of file-oriented systems. Despite its disadvantages, the file-oriented approach is still widely used and, in many situations, serves its users very well.

The Data Base Approach

As the number of applications and data files increased, organizations recognized a need for a data storage approach that was oriented toward the organization as a whole. The data base approach came into being during the 1970s to solve many of the problems of file-oriented systems. The philosophy behind the data base approach is that data are an organizational resource that should be used by and managed for the entire organization, not just the creating department or function. This goal is achieved by combining related application files into larger "pools" of data called data bases, which can then be accessed by many different application programs. For example, an employee data base might consolidate data formerly segregated in separate files such as a payroll file, a personnel file, and a job skills file.

A **data base** is a set of interrelated, centrally coordinated data files. The data stored in the data base are independent of both the computer programs using them and the secondary storage devices on which they are stored. The specialized computer program that manages and controls the data and interfaces between

Figure 8.3
Disadvantages of the file-oriented approach.

The file-oriented approach has the following disadvantages.

- ◇ *Data redundancy.* The same item of data often is included in more than one file. Duplication is costly and inefficient and requires that multiple files be updated each time the duplicated data change. The separate file maintenance programs must be coordinated to ensure that each file is properly updated.
- ◇ *Data inconsistencies.* When duplicate data are stored on separate files, data inconsistencies are likely to arise. Long-term inconsistencies arise when an item is not updated or changed on all files. Temporary inconsistencies occur when there is a time lag between the updating or changing of the duplicated data items.
- ◇ *Costly development of new applications.* New applications development may be costly because of the need to create new files, redesign existing files, or develop interfaces between existing data.
- ◇ *Lack of data integration.* Most file-oriented systems are limited to predetermined information requests. Because data are spread over different files, it often is difficult to respond to unanticipated information requests. Responding to the information requests is usually very costly and requires that a new computer program be written. The information can rarely be produced on a timely basis. By the time the information has been produced, it is often either no longer required or no longer useful.
- ◇ *Large number of data files.* Each of the large number of files requires periodic updates, backups, cataloging, and other processing. Data organization and management often becomes time-consuming and expensive.
- ◇ *Program/data dependence.* File-oriented programs typically contain references to the specific format and location of data stored on files. Changes to the data on the file usually require that changes be made to all the programs that use the files. In organizations that use thousands of programs to process hundreds of files, it becomes very difficult to keep track of what data fields are used by which programs. Thus program maintenance can consume a significant amount of time in file-oriented systems.
- ◇ *Lack of data compatibility.* Because each application file is independent, there usually is little standardization of field names or lengths, attribute values, data representation, and so forth. For example, the product description field might be called P_DESC on one file and Prod_D on another. One file might allow twenty spaces for the description, whereas another might allow thirty.
- ◇ *Lack of data sharing.* This problem occurs when the "owner" of data is unwilling to share the data or when an entity developing a new application is not aware of the data's existence elsewhere in the organization.

the data and the application programs is the **data base management system** (DBMS). The combination of the data base, the DBMS, and the application programs that access the data base through the DBMS is the **data base system.** The person responsible for creating, updating, maintaining, and controlling the data base is the **data base administrator** (DBA). Data base management systems and the role of the data base administrator are explained in greater depth later in the chapter.

Advantages of the Data Base Approach. Figure 8.4 illustrates the differences between the file-oriented approach to data processing and the data base approach. Note that the redundancy of data items B and E shown under the file-oriented approach does not exist under the data base approach. In the file-oriented approach, each program has its own fixed data file, whereas in the data base approach, the data exist separately, or independently, from the programs. Thus the data base approach provides **data independence.**

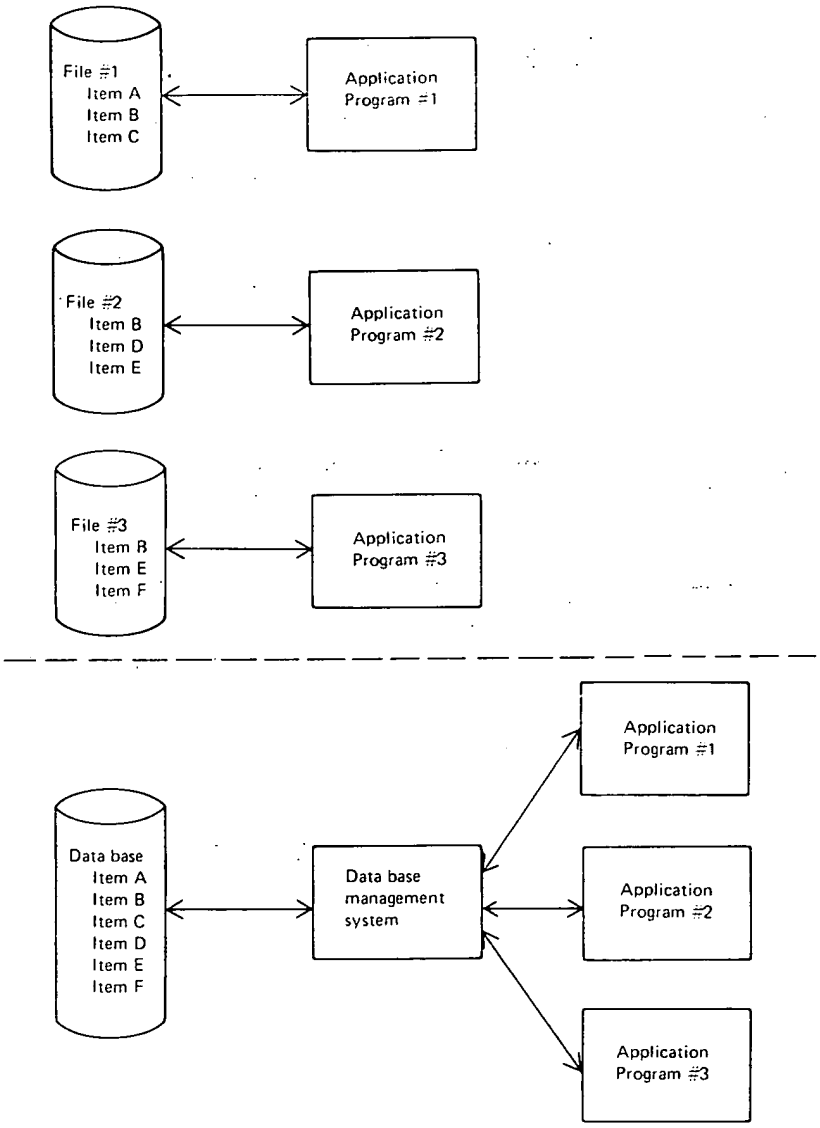


Figure 8.4
File-oriented approach vs. data base approach.

In file-oriented systems, a manager's ability to obtain information from data files is often constrained by the limitations of the system. For example, generating special-purpose reports involving data from two or more separate applications could take so long to complete that the report would not be timely enough to be useful. Data base systems have substantially fewer limitations. For example, with a data base system, a manager can get answers to such questions as "Which parts are supplied by GHI Corp.?" and "Which deliveries are past due?" on short

notice. A data base also can be used to identify entities possessing more than one specified attribute. Answers to questions such as "Which employees in the Engineering Department speak Spanish?" and "Which parts used in the Claven product line are supplied by GHI Corp.?" fall into this category.

The reporting capabilities of a data processing system are substantially enhanced by data base capabilities. Report formats can be revised easily in response to managerial needs. Reports can be generated on an "as-needed" basis instead of, or in addition to, on a regular weekly or monthly schedule. By using the interactive capability of a data base system, a manager can browse through the data base to search for causes underlying the problems highlighted on an exception report, or to obtain detailed information underlying a summary report. The interactive feature of the system also enables the manager to formulate new questions based on the system's response to previous questions.

Data base systems support "cross-functional" data analysis much more readily than do file-oriented systems. Cross-functional refers to the analysis of data relating to different functional areas of the business, such as marketing and accounting. Many data relationships are cross-functional in nature, such as the association between dollar sales and marketing regions, or between selling costs and promotional campaigns. A file-oriented system is typically capable of maintaining only a few such relationships among data elements. In a data base system, most or all such relationships may be explicitly defined and used in the preparation of management reports. A greater variety of reports in terms of content and format is thus possible. Further, the system is more capable of responding to unforeseen managerial requests of an unusual nature that arise on short notice.

By combining related files, records, and data elements into a data base, **data redundancy** can be eliminated or minimized and data inconsistencies avoided. The data base approach can also help standardize operations and data names, synchronize file updates, reduce the duplication of processing, and increase the availability of data. These and other advantages of data base systems are summarized in Fig. 8.5.

Disadvantages of the Data Base Approach. Although data bases have a number of significant advantages over file-oriented systems, they are not always the best way to organize and access data. Data bases have a number of disadvantages that make their use inappropriate in certain situations. Possibly the most important disadvantage is cost. Mainframe data base systems may require both a greater quantity of and more expensive hardware and software than file-oriented systems. The data base package itself is often expensive to lease, purchase, or develop. Some mainframe data bases cost up to $100,000. In addition, more highly trained (and therefore more costly) personnel are usually required to install, operate, and maintain a data base system. The highly trained people are necessary because of the complexity of a DBMS. This complexity, along with the newness and unfamiliarity of DBMS technology, can create complications and undesirable behavioral reactions among the users of the system. These reactions can increase system costs, reduce the efficiency of the system, and lead to delays in implementing the system.

Figure 8.5
Advantages of the data base approach.

The data base approach has the following advantages.

- ◇ *Minimal data redundancy.* Pooling of multiple files means each data item need be stored only once, unless duplication is necessary to enhance system performance. Pooling usually reduces the amount of storage space needed for the data.
- ◇ *No data inconsistencies.* Since only one copy of each item is stored, the data inconsistency found in file-oriented systems is eliminated.
- ◇ *No duplicate processing.* With data stored only once, updates are more efficient, since data only need to be entered once and updated once. The elimination of duplicate processing improves data integrity.
- ◇ *Data independence.* In a data base system, the physical organization of data is not tied directly to specific applications. Instead, data are stored independently of the programs that use them, and DBMS software interfaces between the data and the application program. The application programs need not specify the structure or format of the data or be aware of any of the other physical details of storage, since the DBMS manages the data storage and retrieval tasks. This approach frees the user from concern with the mechanical aspects of file handling, allowing the user to concentrate on the use of the data. Because the data are independent, the application program need not be changed when changes are made to the data base. The data base can evolve as application usage and information query needs change.
- ◇ *Standardized data.* Without duplicate data, there is no problem with different data names, field lengths, formats, and so on.
- ◇ *Lack of data ownership.* When the organization owns the data, no group has special rights over them. They can be shared by all authorized users.
- ◇ *Central management of data.* A data base administrator is typically responsible for coordinating, controlling, and managing data as a firmwide resource. As a result, data management and coordination usually are more efficient.
- ◇ *Integration of related items.* With related data stored together, data elements can be related to each other more easily. Integration increases a company's ability to quickly and efficiently meet unusual requests for information.
- ◇ *Increased accessibility and flexibility.* When data are pooled and closely interrelated and data management is centralized, the data can be accessed more fully, easily, and quickly. This accessibility makes it much easier to meet users' information demands.
- ◇ *User-oriented inquiry/response capability.* With a DBMS, users can query a data base to retrieve information on an as-needed basis.
- ◇ *Security.* Many DBMS software packages have built-in controls that help ensure data integrity. For example, passwords can be used to limit access to authorized users. Security is often better with data bases because they typically have a data base administrator, one of whose main duties is to ensure the security of the data base.

A DBMS adds an additional layer of systems software. The DBMS software increases storage requirements and may add to the total time needed to execute a data processing task. Also, data base systems are difficult to design and implement. Another possible disadvantage is that some DBMS are machine dependent, which means that they can run only on certain types of computers. Two final disadvantages of a DBMS are its vulnerability and its sensitivity to incorrect data. Since a DBMS is highly integrated and concentrated, it is more vulnerable to hardware and software failures. In the file-oriented approach, the loss of a file affects only a few application programs. In a DBMS, loss of the data base renders inoperable all the applications using the data base. Likewise, in a file-oriented system, an erroneous update affects only a few programs. In a DBMS, it affects all applications using the data item erroneously updated.

Despite these weaknesses and shortcomings, the use of data bases is growing. More and more organizations are using data base technology and reaping the rewards it offers. It was estimated that over 85 percent of all mainframe computer sites were using data base technology by the end of the 1980s. Data base usage in microcomputer systems is also growing rapidly. Today nearly all new computer based information systems are being implemented using a data base approach.

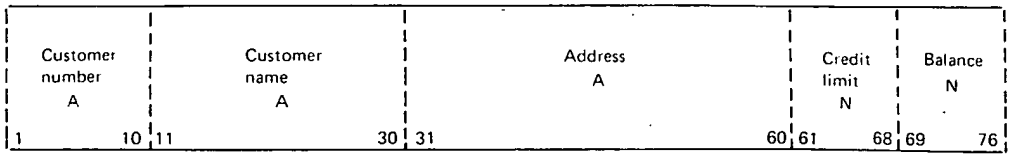
Logical and Physical View of Data

Most file-oriented data storage techniques require the programmer to know the actual physical location and layout of the data records used in the application program. Figure 8.6 shows a record layout of the accounts receivable file introduced in Fig. 8.2. Suppose a programmer needed to produce a credit report showing the customer number, credit limit, and current balance. To write the program, the programmer would usually need to understand the technical characteristics of the hardware, how the data are stored, the location of the fields needed for the report (i.e., record positions 1 through 10 for customer number), the length of each field, the format of each field (alphanumeric or numeric), and so forth. The process becomes more complex if the programmer needs to access several files to obtain the data needed for the report.

Data base systems overcome this problem by separating the storage of data elements from the use of those data elements. In other words, the data base provides two separate views of the data. These are referred to as the physical and the logical view of the data. Figure 8.7 shows the accounts receivable data and the two views of these data.

Logical View

The **logical view** is the way users conceptually organize, view, and understand the relationships between data items. When a system supports a logical view of data, users can access, make queries of, or update the data stored in the customer data base without reference to how or where the data are stored. With the data



A = Alphanumeric
N = Numeric

Figure 8.6
Accounts receivable file record layout.

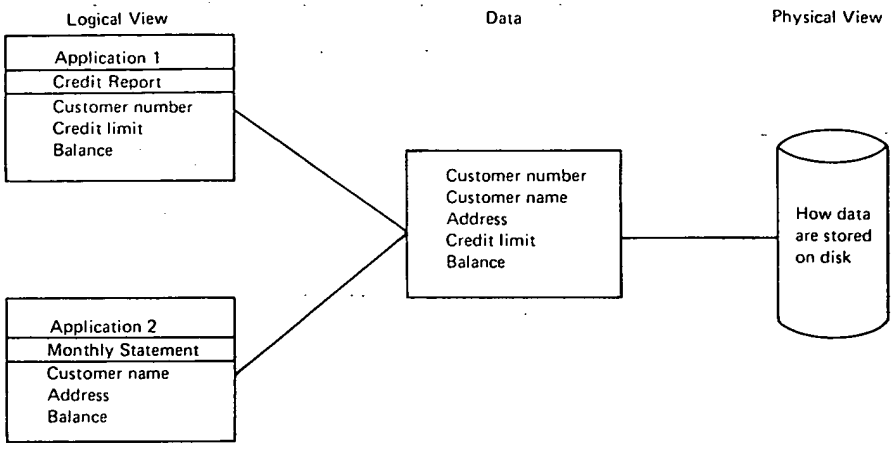


Figure 8.7 *Logical and physical views of data in a customer data base.*

base approach, a user could produce the monthly statement in Fig. 8.7 without understanding the details of how the data on the report are physically stored on disks, tapes, or other media. The user or analyst is responsible only for defining the logical data requirementse of the application.

Separating how data are used from how they are stored and accessed means that users can change their logical view (the data items needed) without making changes in the physical view (the physical storage of the data). Likewise, the data base administrator can change the physical storage of the data without the user's having to change the application programs.

A model of the overall logical organization of a data base is referred to as the conceptual **schema** (plural: schemata). The schema describes the types of data elements in the data base (fields, records, files, etc.), the relationships between the data elements, and the structure or overall logical model used to organize and describe the data. A subset of the schema that includes only those data items used in a particular application program or by a particular user is referred to as a **subschema** (or **user schema** or **view**). The subschema is more than just the data items in an application; it is also the way the user defines the data and the data relationships. It is, therefore, a part of the conceptual schema that defines the entire data base.

In Fig. 8.7, for example, the schema consists of all the data: the customer number, name, address, credit limit, and balance. The subschema, or user view, for Application 1 consists of the customer number, credit limit, and balance. The subschema for Application 2 is the customer name, address, and balance. From a given schema, several subschemata may be derived—one for each of the programs that access the data base.

Physical View

The **physical view** is bits- and bytes-oriented and refers to how and where data are physically arranged and stored on disks, tapes, and other media. EDP personnel use this view to make efficient use of storage and processing resources.

The person responsible for the data base, called the data base administrator, is responsible for physically storing the data in a way that will allow the logical requirements to be met. Programmers and users, however, generally have no need for physical information, since they are only interested in using the data, regardless of how it is stored.

Data Base Management Systems

What is the difference between the file-oriented approach and the data base approach? How can the file-oriented approach be data dependent, whereas the data base approach provides data independence? How are the logical and physical views coordinated in the data base approach? The answer to these questions lies in a complex software package—the DBMS.

Although each user may have his or her own separate logical view of the data, the system stores the data in only one way. DBMS software provides the link between the actual organization of the data on file storage media and the various logical views of the data in the minds of the users. In some cases the physical data organization that optimizes data storage factors such as access time and capacity utilization may differ from the logical data organization best suited to the needs of data users. Data items such as customer account balance, name, address, and credit history may be stored in separate locations, or even on separate devices, even though users perceive a close logical relationship between them. It is the responsibility of the DBMS to manage the data base in such a way that users may work effectively with logical sets of data items, without being aware of the complexities involved in the physical organization of those sets of data items. Ideally, the system should appear to each user to behave as if the data were physically stored in exactly the way in which that user logically views them.

One of the most significant differences between the processing of traditional files and the processing of data bases is that traditional files are processed by only a small number of programs, each doing its work at a separate time, whereas data bases can be processed by several programs, some of which may be working on the same data base concurrently. In this situation, there is a danger that errors may be introduced into the data base when different programs attempt to use or modify the same data items simultaneously. Data base management systems must have the capability to deal with multiple concurrent updates.

DBMS Languages and Interfaces

Most DBMS packages contain a number of different languages and interfaces. Although each package is different, this section describes some of the more common components of a DBMS. The **data definition language** (DDL) ties the logical and physical views of the data together. It is used to initialize or create the data base and to describe the schema and each individual subschema, as well as to describe all the records and fields in the data base. The DDL is also used to

specify any security limitations or constraints that are imposed on records or fields in the data base.

The **data manipulation language** (DML) is used to update, replace, store, retrieve, insert, delete, sort, and otherwise manipulate the records and data items in the data base. Because of the DML, a user can accomplish these manipulations by using data names, rather than by referring to the physical storage locations of the items. The DML also provides an interface to the programming languages used by the applications programmers.

The **data query language** (DQL) is a high-level language used to interrogate the data base. Most DQLs contain a fairly powerful set of commands that are easy to use yet provide a great deal of flexibility. They make it possible for users to satisfy many of their information needs without having to involve an applications programmer. An example of a DQL is Structured Query Language (SQL), a package produced by IBM. Figure 8.8 illustrates the SQL language.

The query language is typically available to all users. Use of the data base definition language and the data manipulation language is often confined to the data base administrator and the applications programmer, respectively. Restricting these languages to their respective users helps maintain proper control.

Report writers are similar to data query languages. All users need to do is specify the data elements to be printed and the desired output. The report writer searches the data base, extracts the desired items, and prints them out in the user-specified format.

Figure 8.8
Examples of a data query language.

Structured Query Language (SQL) Query:

```
SELECT      NAME,EXPERIENCE
FROM        PER. RECORDS
WHERE       DEPT = DP AND EXPERIENCE > 7
            AND LANGUAGE = SPANISH
ORDER BY    EXPERIENCE,DESC
```

Sample Output:

NAME	EXPERIENCE
Carter, V.	30
Sheide, G.	23
Nielson, G.	21
Wilson, M.	19
McMahon, J.	17
Young, S.	15
Bosco, R.	13
Detmer, T.	8

This query selects (the SELECT command) the fields named Name and Experience for all records in the file PER.RECORDS (the FROM command) that meet specified criteria (the WHERE command). The stated criteria are that they work in the data processing department, that they have more than 7 years of experience, and that they speak Spanish. The selected fields from the records are printed out in descending order (the ORDER BY and the DESC commands) based on their number of years of experience.

Figure 8.
Data base and how i interface data base

DBMS Functions and Users

The functions of a DBMS may be divided into three board categories: creation, maintenance, and interrogation. Data base creation includes defining, organizing, creating, and revising the content, relationships, and structure of the data needed to build a data base. Data base maintenance involves adding, deleting, updating, changing, and controlling the data in the data base. Data base interrogation is querying the data base in order to access the data needed to support information retrieval and report generation. The three DBMS functions are related to the three different types of users who typically interact with the data base, as illustrated in Fig. 8.9.

Data Base Administrator. The DBA is responsible for coordinating, controlling, and managing the data in the data base. The DBA can be thought of as the human equivalent of the DBMS. That is, the DBA not only must be aware of users and their data requirements, but also must understand how the DBMS operates and how data are stored and processed. In other words, the DBA must understand both the users and the technical data storage side of the system so that he or she can make sure the system meets the needs of users. This concept is illustrated in Fig. 8.10.

The DBA typically has the following major responsibilities:

◇ To help establish the data models that describe the relationships among the data used in the organization.

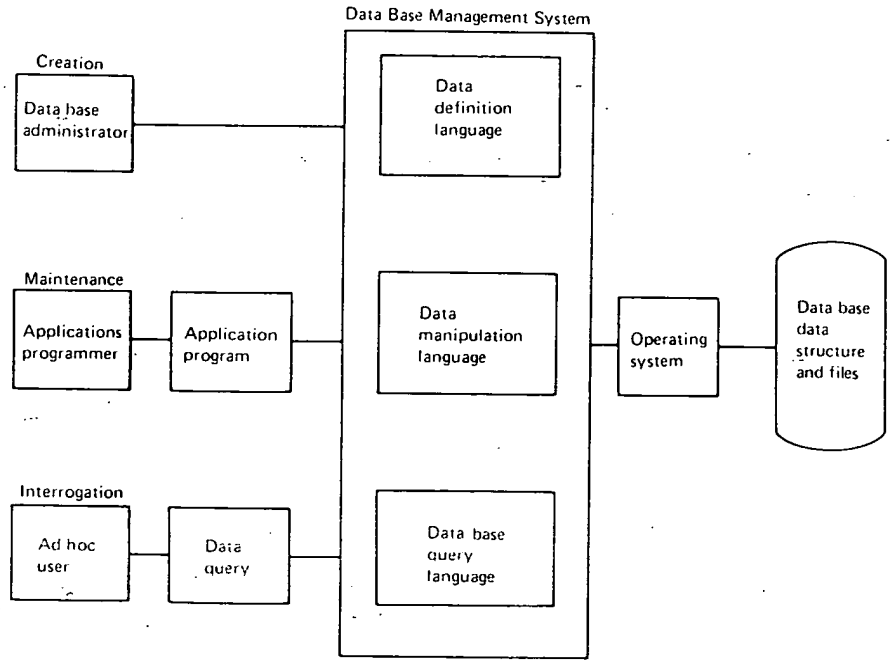


Figure 8.9
Data base users and how they interface with the data base system.

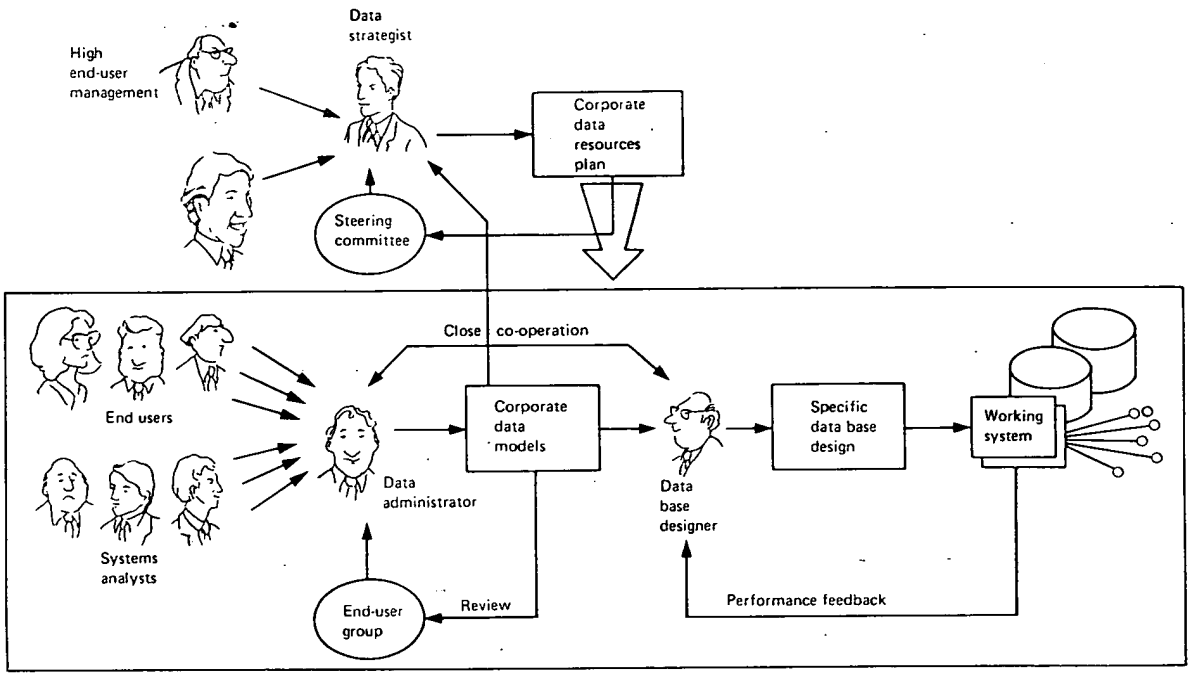


Figure 8.10
Responsibilities of the data base administrator. (James Martin, An End-User's Guide to Data Base, *© 1981, p. 33. Reprinted by permission of Prentice-Hall, Inc., Englewood Cliffs, N.J.)*

- ◇ To establish data standards and specifications.
- ◇ To specify the content, relationships, and structures of the data base.
- ◇ To provide for creating, updating, adding to, deleting from, changing, and otherwise maintaining the data base. Responsibilities include approving changes to the data base so that one user cannot change data to the detriment of others who use the same data.
- ◇ To develop retrieval methods to meet the needs of the data base users.
- ◇ To specify and maintain the physical structure of the data base.
- ◇ To maintain a data dictionary (discussed later in the chapter).
- ◇ To provide for adequate control over the data base, through regulation of such areas as editing, security, backup and recovery, and authorization. The DBA function is itself a form of control, since the responsibility for data is taken from users and programmers and entrusted to the DBA.

Applications Programmers. The programs that process the data stored in the data base are developed by **application programmers.** Applications programmers formulate a logical method, or user view, of the data to be processed. Then they write an application program, using a programming language. The application programs are sent to the DBMS, which refers to the appropriate sub-

schema to determine the internal physical schema of the data requested. The DBMS requests the operating system to retrieve the required data, and the DBMS then turns them over to the application program for processing. When processing has been completed, the data are turned back to the DBMS, which instructs the operating system to store them.

DBMS software has greatly expanded the ability of applications programmers to handle complex data structures. It has also simplified the tasks of applications programmers and ad hoc users. As a result, a broader range of timely reports can be produced for users with a smaller investment in programming time and with less difficulty.

Users. Those who use data base information are referred to as users. Users can receive periodic, scheduled reports, or they can query the data base as desired. Users who make unscheduled, as-needed inquiries of the data base are often referred to as **ad-hoc users.** Ad hoc users can receive an immediate response to their query in the form of a screen display or a printed report formatted to meet their specific needs. Data bases have significantly increased the ease and speed with which users can produce reports. Only a few short statements are needed to get answers to questions about company operations. As a result, organizations with data base systems are less dependent on periodic, scheduled reports than are organizations with file-oriented systems.

The Data Dictionary

A data base system cannot be successfully implemented in an organization unless the implementers have a thorough understanding of the data elements used within the organization, where they come from, and how and by whom they are used. This is why taking an inventory of data elements is one of the first steps in the process of implementing a data base system. The information collected during the inventory is recorded in a special file called a **data dictionary.** The data dictionary contains information on both the types of data and the uses of data, as shown in Fig. 8.11.

The data dictionary is a centralized source of data about data. For each data element used in the organization, there is a record in the data dictionary that contains data about that data element. For example, each data dictionary record might contain the name of the data element, its description, the name of the record(s) in which it is contained, the name of the source document from which it originates, its size or field length, and its field type (numeric, alphanumeric, etc.). It might also contain the names of all programs that use it, the names of all output reports in which it is used, the names of people (programmers, managers, etc.) who are authorized to use it, and any data names from other files or systems that are applied to the same data element. Figure 8.12 provides an example of what a data dictionary might contain.

The data dictionary is usually maintained automatically by the DBMS. In fact, this is often one of the first applications of a newly implemented data base system. Inputs to the data dictionary include records of any new or deleted data

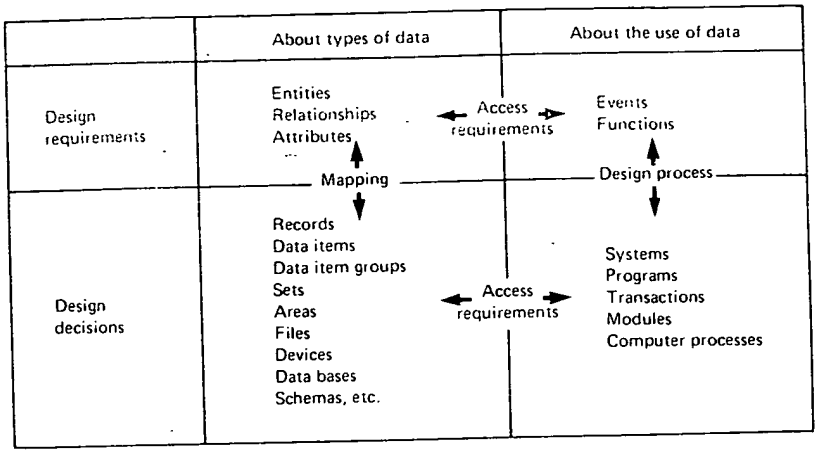


Figure 8.11
The information in a data dictionary. ("The British Computer Society Data Dictionary Systems Working Party Report," Data Base 9 [Fall 1977]:5.)

elements, as well as changes in names, descriptions, or uses of existing data elements. Outputs include a variety of reports useful to programmers, data base designers, and users of the information system. Sample reports include a list of all programs in which a data item is used, a list of all synonyms for the data elements in a particular file, a list of all data elements used by a particular user, and a list of all output reports in which a data element is used. Reports of this type are extremely useful in the design and implementation of a data base system, as documentation of the system, and as an audit trail.

The accountant has a very good understanding of the data elements that exist in a business organization, where they originate, and where they are used. This knowledge is a result of the accountant's role in the design of information systems and in the processing of financial data. Therefore an experienced accountant should play a key role in the development of the data dictionary.

Commercially Available DBMS Packages

Few organizations attempt to write their own DBMS software, because the complex and sophisticated programming involved makes it cost-ineffective. Instead, they purchase or lease one of the commercially available data base packages. Although data base packages are available for most models and makes of computers, the available packages can be divided into two categories: mainframe and microcomputer packages. These packages sell for as little as $200 for microcomputer data bases to up to $100,000 for mainframe data bases. In general, the larger the computer and the more expensive the package, the more powerful, flexible, and versatile the package. Figure 8.13 lists a few of the more popular packages in these two categories, along with the companies that sell them. As with any other software, users who are selecting a data base package should carefully evaluate the available packages to ensure that they select the package that best meets their needs.

DATA DICTIONARY

Data Element Name	*Description*	*Records in Which Contained*	*Source*	*Field Length*	*Field Type*	*Programs in Which Used*	*Outputs in Which Contained*	*Authorized Users*	*Other Data Names*
Customer number	Unique identifier of each customer	A/R record, customer record, sales analysis record	Customer number listing	10	Alphanumeric	A/R update, customer file update, sales analysis update, credit analysis	A/R aging report, customer status report, sales analysis report, credit report	No restrictions	None
Customer name	Complete name of customer	Customer record	Initial customer order	20	Alphanumeric	Customer file update, statement processing	Customer status report, monthly statement	No restrictions	None
Address	Street, city, state, and zip code	Customer record	Credit application	30	Alphanumeric	Customer file update, statement processing	Customer status report, monthly statement	No restrictions	None
Credit limit	Maximum credit that can be extended to the customer	Customer record, A/R record	Credit application	8	Numeric	Customer file update, A/R update, credit analysis	Customer status report, A/R aging report, credit report	R. Drummond W. Francom H. Heaton	CR_limit
Balance	Balance due from customer on credit purchases	A/R record, sales analysis reord	Various sales and payment transactions	8	Numeric	A/R update, sales analysis update, statement processing, credit analysis	A/R aging report, sales analysis report, monthly statement, credit report	O. Cherrington J. Hansen K. Stocks	Cust_bal

Figure 8.12
An example of a data dictionary.

Figure 8.13 *Commonly used DBMS software.*

MAINFRAME DATA BASES	
Package	***Vendor***
ADABAS	Software AG
DATACOM DB	Applied Data Research
DB2	IBM Corp.
IDMS	Cullinet Corp.
IDS	Honeywell
IMS	IBM Corp.
Model 204	Computer Corp. of America
Oracle	Relational Software, Inc.
RAMIS II	Mathematic Products Group
Systems 2000	Intel Corp.
TOTAL	Cincom Systems, Inc.
FOCUS	Information Builders, Inc.

MICROCOMPUTER DATA BASES	
Package	***Vendor***
dBase	Ashton-Tate
Knowledgeman	Micro-Data Base System
MDBS	International Software Enterprises, Inc.
Paradox	Borland International
PC/FOCUS	Information Builders, Inc.
R:Base	MICRORIM
Revelation	Cosmos

File Organization and Access

All computer systems must have some formalized means of organizing and accessing their data. Users need conceptual models of the data and their interrelationships. In addition, the data must be organized and stored on the physical devices in such a way that they can be accessed easily and efficiently. It is not necessary for accountants to understand the technical details of the storage process. It is important, however, that they understand how files and data bases are organized and accessed, for the following reasons.

- During systems design, accountants typically play a significant role in developing the logical representations of an organization's data. They need to understand the constraints that may be imposed on the logical representation by organization and access methods.
- A system should be designed to meet the needs of the users, and accountants should understand file organization and access methods well enough to select the approach that best meets those needs.
- Organization and access methods significantly affect the efficiency and speed with which records can be created, retrieved, updated, added or deleted, and

Sequen

Rando

otherwise maintained. Each file organization and access method is more efficient at some of these functions than at others. Since systems and file design involves a series of trade-offs, the accountant needs to understand the organization and access approaches in order to make the proper choices.

File organization refers to the way data are stored on the physical storage media. The data may be stored in sequential order or randomly. These methods are referred to respectively as **sequential** and **direct** (or random, nonsequential, or relative) **file organization.**

File access refers to the way the computer finds, or retrieves, each record it has stored. With sequential access, the records are read, one by one, in the sequential order in which they are stored. With direct access, the computer must have some means of locating the desired record without searching each record in the file. Several approaches are commonly used to locate records: individual keys, pointers, indexes, and randomized calculations. These methods are explained later in the chapter.

File access methods are a way of logically organizing the records in a file; thus they are referred to as methods of logical file organization. This section discusses sequential access and three direct methods: hashing, indexing, and multikey (multiattribute) retrieval. Methods of logical data base organization are discussed later in the chapter.

Sequential File Organization

Records in sequential files are stored in numeric or alphabetical order according to the record key (for example, customer numbers from 00001 to 99999). The sequence of the records in the file can be changed by sorting the file according to a new key (for example, by customer name rather than customer number). To access a sequential file record, the system must start at the beginning of the file and read each record. As each record is read, its key is compared with the key of the desired record. This process continues until the desired record is located. Unfortunately, the entire file has to be read to find the items stored at the end of the file.

Sequential file organization is common for a number of reasons. It can be used both on the less expensive sequential media like magnetic tapes and on the more versatile and flexible random access devices like disks. Its usage is consistent with periodic business reporting processes such as weekly payroll and monthly billing. In addition, it is very efficient for batch processing operations. The approach's disadvantages include inefficient retrieval of individual records and unavailability of up-to-date records. The advantages and disadvantages of sequential file organization are further explained in Fig. 8.14.

Random (Direct) Access Organizations

With a random access storage medium, transactions can be processed as they occur, instead of being accumulated in batches prior to processing. When a transaction or other event affecting the master file occurs, the system searches the file

Figure 8.14
Advantages and disadvantages of sequential file organization.

Advantages of Sequential File Organization

- ◇ Many accounting data lend themselves to ascending sequential order.
- ◇ It is a simple, fast, and efficient method of file organization when a large volume and a reasonably high percentage of records are processed on a periodic basis (batch processing).
- ◇ Since the records are generally stored in the order in which they would be printed, it facilitates applications that require frequent printouts or screen displays of all or most of the file.
- ◇ It makes efficient use of storage space, since records are stored sequentially with no gaps (except as needed to read the data) between them.
- ◇ It makes efficient usage of less expensive storage media such as tapes.

Disadvantages of Sequential File Organization

- ◇ It is impractical for applications that require immediate access to records, because the search process is inefficient. On average, one half of the records must be searched to locate a record.
- ◇ Records are up-to-date only immediately after the update process takes place. That is, transactions that occur between updates are not reflected in the file.
- ◇ Both master and transaction files must be sorted in the same order.
- ◇ The whole file must be searched in order to add, delete, or modify a data record.
- ◇ When a sequential storage medium is used, a new file must be created each time a change is made to the file.

for the desired master record. When found, it is read into the computer and updated. It is then written back out to its original physical location on the direct access storage medium. Since the "new" (updated) record is written over the "old" record, the old record is lost unless it is first written to a separate file.

Random access methods are used when it is not practical or possible to anticipate the sequence in which records will be processed or queried, or when other significant advantages of the approach are desired. The major difficulty in implementing the random access approach is determining storage locations for the records. To determine storage locations, a relationship between the storage location and the record key must be established. Three methods of establishing such a relationship are hashed file, indexed file, and multiattribute search file organization.

Hashed File Organization. For some records, it may be possible to establish an equivalence between record keys and machine addresses. For example, invoices 0001 to 9999 may be stored at storage addresses 0001 to 9999. This method, called **direct addressing**, is the fastest form of record addressing. This method, however, cannot be used with the coding systems on which most sets of record keys are based, because there is no one-to-one correspondence between the coding system and the storage addresses. An alternative, called **hashing, key transformation,** or **randomizing,** is to perform an arithmetic calculation on the key to convert it into a near-random number. This number is then converted into the address where the record is to be stored or from which it is to be retrieved.

One common form of hashing is the division remainder method. With this method, record addresses are found by dividing the record key by a prime num-

ber approximately equal to the total number of storage addresses required for the file. The quotient is discarded, and the remainder is used as the record address. For example, suppose 2400 employee records are to be stored in blocks of five in 500 storage addresses numbered from 000 to 499. When the key (social security number) is divided by 499, the prime number closest to 500, a remainder ranging from 0 to 498 will result. Ideally, each of the 499 possible remainders will be obtained approximately five times. This system minimizes the number of unused storage locations and the number of overflow locations needed to store additional records (called **synonyms**) with the same physical storage address. There are several ways to handle overflow, such as using an adjacent storage location, using a separate overflow area, and using a pointer to indicate the location of the synonym.

The advantages of hashing are its flexibility, the speed with which records can be stored and retrieved, and the ability to find a record without a sequential search. In addition, records can be added or deleted without concern for physical sequencing. Disadvantages are the presence of unused storage locations, the possibility that there may be too many records for a particular location, and the need to provide for overflow storage locations. Another potential disadvantage is the inability to handle large volumes of transactions efficiently.

Indexed File Organization. A second way to access records directly is to use an index, or directory. Indexed file organization makes use of two different files: the file containing the data records and an index file. The **index file** stores record identifiers and the physical addresses of the records in the data file.

An index file is used the same way a card catalog in a library is used. To find a book in the library, you could examine each book on each shelf in some predetermined sequence. However, this sequential examination would be extremely time-consuming. Instead, you go to the card catalog, determine the approximate physical location of the book, proceed to the shelf that holds the book, and search that shelf for the book. In a similar fashion, an index file can be used to find a record in a data file. The following steps are followed:

1. The user requests a specific record by specifying its key.
2. The index is read into primary memory, if necessary, and accessed.
3. The index is searched to find the desired key. This search may be time-consuming, especially if the index is large. To shorten the search time, an index to the index is sometimes used to help zero in on the key being sought.
4. Once the key has been located in the index and the corresponding address has been obtained, the block of records comprising the contents of that address is read into primary memory.
5. Finally, the records in that block are searched to find the specific record desired.

Files can be fully or partially indexed. In a fully indexed file, there is an entry in the index file for every record in the data file. In a partially indexed file, the index contains one entry for every nth key, where n is the number of records that fit in each storage location. Fully indexed files are much larger than partially indexed files and require more storage space and a greater access time.

The most popular indexing approach is the **indexed-sequential access method** (ISAM). With this approach, records are stored in sequential order by their primary key on a direct access storage device. Because records are stored sequentially, the file can be used like any other sequential file. However, an index file is also created and used with the file. This means that the file can also be accessed randomly. In other words, an ISAM file has the advantages of both sequential and random file organization. Either file processing method can be chosen, depending on the specific business needs.

The ISAM approach does have drawbacks, however. It is slower than direct organization and takes more storage space, because of the index. In addition, creating, storing, and maintaining the indexes can be costly. Finally, large quantities of new records cannot be added easily to the file. To help solve the problem of additions and deletions, the file can be reorganized periodically.

Figure 8.15 is an example of an indexed-sequential file. In this example, twenty-five customer records numbered from 1478 to 1502 are stored in blocks of five in five storage addresses numbered from 4061 to 4065. The index contains five

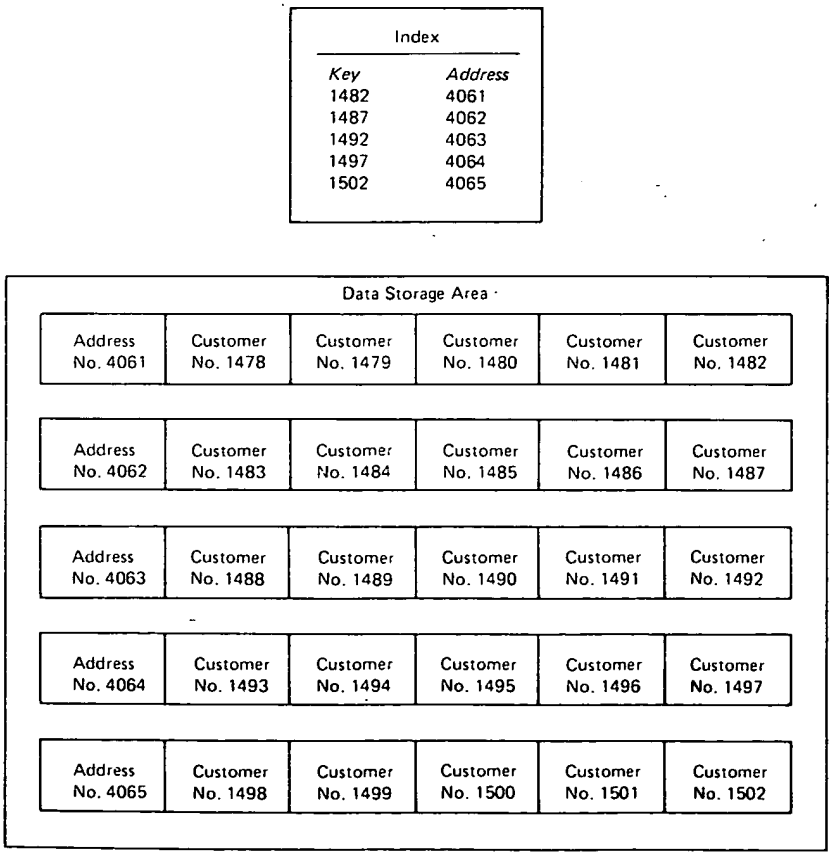


Figure 8.15
An indexed-sequential file.

Figure 8.
Parts recc chained o secondar using emi pointers.

entries—one for each address. Each index entry contains the key of the last customer record in the block and the address of that block.

Multiattribute Search File Organization. The three file organizations previously described allow the file to be accessed by the primary key, but they do not facilitate the access of data records based on one or more secondary keys. When access through secondary keys is desired, a multiattribute search file organization is used. Two methods are discussed here: linked lists and inverted lists (also called inverted files).

Linked Lists. In a **linked list,** each data record has a pointer field containing the address of the next logical record in the list. Thus all logically related records are linked together by pointers. A group of records "connected" by pointers is referred to as a list or a **chain.**

Figure 8.16 illustrates the use of embedded **pointers** to chain together parts records having the same secondary keys. Each record is assumed to reside in a storage location coded with a two-digit machine address. For each of the two secondary keys, supplier and product line, there are four different chains—one for each of the four possible values that each secondary key can assume. The links in each chain are pointers contained in the fields labeled "Next S" and "Next PL." Each of these fields "points to" the storage address of the next record having the same value for supplier and product line, respectively. For example, the chain for all parts supplied by ABC Co. may be traced through the records at machine addresses 11, 16, 17, 21, and 30.

A linked list may be connected by means of a forward pointer, which starts with the first record, or head of the list, and proceeds to the end of the chain. Records may also include backward pointers, which point to the prior record in the list, and parent pointers, which point to the head of the list. The use of backward and parent pointers facilitates recovery of pointers damaged or lost because of a system malfunction of some kind.

Figure 8.16
Parts records chained on two secondary keys using embedded pointers.

Address	Part No.	Supplier	Next S	Product Line	Next PL
11	125	ABC Co.	16	Widget	17
12	164	XYZ Inc.	14	Doodad	16
13	189	GHI Corp.	18	Clavet	15
14	205	XYZ Inc.	24	Lodix	18
15	271	RST Mfg.	19	Clavet	22
16	293	ABC Co.	17	Doodad	20
17	316	ABC Co.	21	Widget	23
18	348	GHI Corp.	20	Lodix	19
19	377	RST Mfg.	22	Lodix	21
20	383	GHI Corp.	23	Doodad	24
21	451	ABC Co.	30	Lodix	25
22	465	RST Mfg.	25	Clavet	27
23	498	GHI Corp.	26	Widget	·
24	521	XYZ Inc.	28	Doodad	26
25	572	RST Mfg.	·	Lodix	28
26	586	GHI Corp.	27	Doodad	29
27	603	GHI Corp.	29	Clavet	·
28	647	XYZ Inc.	·	Lodix	30
29	653	GHI Corp.	·	Doodad	·
30	719	ABC Co.	·	Lodix	·

There are many uses for linked lists and pointers. A common use in accounting systems is linking a set of detail records to a master record. For example, an accounts receivable record may have associated with it a number of transaction records, which could be connected to it by means of linked lists. Similarly, an invoice or purchase order record could have line-item records connected to it using pointers. Another use of chains is to link together all records in a file that meet a particular criterion, such as all accounts past due. Chains may also be used to link together all records in a file that have the same secondary key, such as all employees who work in the same department.

Linked lists have several advantages. They reduce record redundancy, because a record that is physically stored only once may be a member of several lists. If the records are chained together in a particular sequence, then it may not be necessary to perform a time-consuming sort operation when they must be processed in that sequence. Linked lists also facilitate the retrieval of records whenever their physical sequence does not correspond to the desired logical sequence. For example, employee records may be in sequence by employee number, but a user may wish to retrieve only those for a particular department.

Linked lists have some significant disadvantages as well. First, additional storage space is required for the pointers. Second, and more significantly, lists must be updated as new records are added, old records are deleted, and linked data within current records are modified. The need to update the pointers adds considerably to the complexity of the file updating process.

Inverted Lists. Whereas linked lists use pointers embedded within the records, inverted lists use pointers stored in an index. An **inverted file** is one in which inverted lists are maintained for some of the attributes. A file is fully inverted if there are inverted lists for every one of its attributes. A partially inverted file is one in which inverted lists are maintained for some but not all attributes.

Figure 8.17 shows inverted lists for the secondary keys supplier and product line, created from the sample data records in Fig. 8.16. There is one list for each value of each attribute, and each list contains the machine addresses of all records having that value. Using these inverted lists, any or all records containing a particular supplier or product line can be easily and quickly accessed.

Multiple indexes can also be compared so that records with the same attributes can be located. For example, a search routine could examine the following three indexes of the personnel file: foreign language, experience, and department. All

SUPPLIER	ADDRESSES	PRODUCT LINE	ADDRESSES
ABC Co.	11, 16, 17, 21, 30	Clavet	13, 15, 22, 27
GHI Corp.	13, 18, 20, 23, 26, 27, 29	Doodad	12, 16, 20, 24, 26, 29
RST Mfg.	15, 19, 22, 25	Lodix	14, 18, 19, 21, 25, 28, 30
XYZ Inc.	12, 14, 24, 28	Widget	11, 17, 23

Figure 8.17
Inverted lists for the secondary keys of Fig. 8.16.

records with the common attributes Spanish, more than seven years' experience, and data processing could then be selected. This would allow the company to find the employees who speak Spanish, have more than seven years of experience, and are in data processing. Such information might be used to help the company fill a foreign assignment. Since the index, rather than the file, is searched for the attribute values, the information retrieval approach is very efficient.

The basic advantage of inverted files is that they facilitate the retrieval of information. The disadvantages of inverted files are that the indexes often require a substantial amount of storage space and must be updated each time the data records are updated.

Data Base Organization and Access

Most modern data bases contain records and files that are interrelated. The relationships fall into different categories called **logical data structures** or **models.** The logical model selected by users depends on their conceptual view of the data and what they want to accomplish. The three basic logical models—tree (or hierarchical), network, and relational—will be discussed in this section. Although a flat file is theoretically a physical implementation of data, because of its frequent use it too is covered in this section.

Flat File Structure

A **flat file** is a file structure in which each record is identical to every other record in terms of attributes and field lengths. A simple example of a flat inventory file appears in Fig. 8.18. Notice that each record maintains data on an identical set of attributes—stock number, description, color, vendor, quantity on hand, and price. Further, the field size available for each attribute is identical for each record. These characteristics are typical of many accounting files.

A significant advantage of a flat file is that it can be viewed as a table where the rows are records and the columns are attributes. Records can easily be selected by establishing selection criteria for one or more attributes (columns). Flat

Figure 8.18
A flat file.

STOCK NUMBER	DESCRIPTION	COLOR	VENDOR	ON HAND	PRICE
1036	Refrigerator	White	Gibman	12	$349.99
1038	Refrigerator	Yellow	Gibman	07	$359.99
1039	Refrigerator	Copper	Gibman	05	$379.99
2061	Range	White	Hotspot	06	$489.99
2063	Range	Copper	Hotspot	05	$499.99
3541	Washer	White	Whirlaway	15	$349.99
3544	Washer	Yellow	Whirlaway	10	$359.99
3785	Dryer	White	Whirlaway	12	$249.99
3787	Dryer	Yellow	Whirlaway	08	$259.99

files are frequently used as the basic physical implementation approach for the relational model discussed later in this section.

Tree (Hierarchical) Data Base Structure

A **tree** is a data structure, or logical data model, in which relationships between data items may be expressed in the form of a hierarchical structure (see Fig. 2.1). A customer file in which data relationships are represented in the form of a tree structure appears in Fig. 8.19. This tree consists of four **nodes**, which are the record types: customer data, credit transactions, invoices, and invoice line items. The uppermost record type, which in this case contains the customer data, is referred to as the **root** of the tree. One characteristic of a tree is that each node other than the root is related to one and only one other node at a higher level, which is called its **parent.** Each node, however, may have one or more nodes related to it at a lower level, and these are called its **children.** The tree structure is implemented and controlled using pointers and chains.

The arrows in Fig. 8.19 show the data relationships. In the diagram, each line between a parent and child has one arrow pointing to the parent and two arrows pointing to the child. This indicates that each represents a **one-to-many** (1:M) relationship—each child has only one parent, but each parent may have several children. For example, each invoice is associated with only one customer, but each customer may have several invoices. Also, each line item belongs to a single invoice, but a given invoice may have several line items. In a one-to-many relationship, the child record is referred to as a **repeating group.** Such relationships are common in accounting records. For example, a company can have several sales offices, each sales office can have several salespeople, each salesperson can have several customers, each customer can make several purchases, and each purchase can include several items.

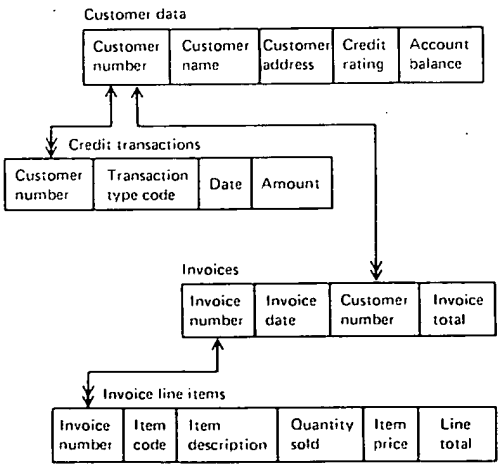


Figure 8.19
Customer accounts data in a tree structure.

Figure 8.2
Accounting files in a n structure.

Network Data Base Structure

In traditional business systems, virtually all files are either flat files or trees. For example, a manual system might consist of a separate file folder for each customer, containing an account ledger card and copies of invoices, remittance advices, and credit memos. If such records were computerized, they would undoubtedly continue to be structured in the form of a tree, as shown in Fig. 8.19.

Relationships too complex to be expressed in the form of trees or flat files often exist among data items or groups of items. Consider the company whose customer accounts data structure appears in Fig. 8.19. This company probably also maintains a separate file of general ledger accounts in which invoices sent to customers and credits to customers are entered as transactions. Furthermore, the organization may have an inventory file in which sales to customers are recorded as reductions in the quantity on hand. In flat file and tree structures, such relationships among data in separate files are not recognized explicitly. One data structure in which it is possible to explicitly recognize data relationships across files is known as a network.

A **network** may be defined as a data structure involving relationships among multiple record types such that (1) each parent may have more than one child record type (as in a tree) and (2) each child may have more than one parent record type (not possible in a tree). For example, if we add the record types "general ledger account" and "inventory records" to the data structure of Fig. 8.19 and incorporate the relationships mentioned in the preceding paragraph, we obtain the network data structure illustrated in Fig. 8.20. Note that, in accordance with the definition of a network, the child record type "credit transactions" has more than one parent record type—both "general ledger accounts" and "customer data." The record type "invoices" has the same two parents. Also, both "invoices" and "inventory records" are parents of "line items."

A fundamental characteristic of business records is that records in one file tend to be related to records in one or more other files. Thus virtually all business records can be structured as a network if the data base user uses a network structure to define the schema. Figure 8.20 is one example of such a schema. Separate users may then define separate subschemata using either a flat file, tree, or network structure. The tree structure in Fig. 8.19 is an example of one subschema that could be derived from the schema in Fig. 8.20.

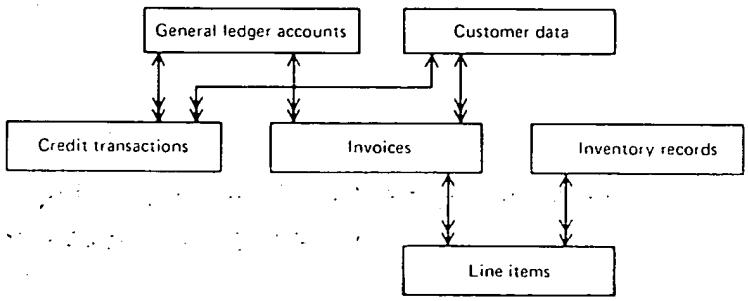


Figure 8.20
Accounting data files in a network structure.

Each of the data relationships represented in Fig. 8.20 is a one-to-many relationship. One additional characteristic distinguishing network structures from tree structures is that a network structure may contain one or more **many-to-many** (M:M) relationships. In a many-to-many relationship, a particular occurrence of a child record type may be owned by one or more occurrences of its parent record type. For example, consider the relationship among production parts, subassemblies, and finished products as diagrammed in Fig. 8.21. A subassembly may consist of several parts, and a product may consist of several subassemblies and parts, which is consistent with a one-to-many relationship. In addition, however, a given part may be included in several different subassemblies or products. Therefore each of the three relationships shown in the schema is a many-to-many relationship; in the diagram the double arrows going in both directions represent many-to-many relationships.

A network in which all the data relationships are one-to-many, as in Fig. 8.20, is referred to as a **simple network.** One in which some or all the relationships are many-to-many, as in Fig. 8.21, is referred to as a **complex network.**

The advantage of networks is that many limitations of tree structures can be avoided. More complex logical relationships between records can be represented if many-to-many relationships are allowed. The disadvantages of networks are the complexity and difficulty of use. In most network systems, the user must have specialized training in data processing (including a detailed knowledge of the relationships represented in the network and the physical storage structure used) in order to query or update the network. Networks seem to be best suited for applications that are recurring and voluminous and in which there are relatively few user queries. Correspondingly, a network structure is least useful for applications in which users frequently query the data base.

Relational Data Base Structure

The **relational data base** model was developed as a way of simplifying the complex data relationships used in tree and network structures. The data structures discussed previously require that all data relationships be planned and defined in advance. Often, however, relationships develop that were not anticipated when the data base was organized. Tree and network structures afford little processing

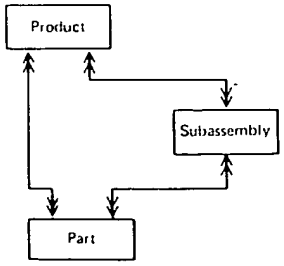


Figure 8.21
A network structure involving many-to-many relationships.

flexibility; when new relationships are needed, the entire data base may have to be redesigned. The problem of handling unanticipated, or ad hoc, data relationships may be partially solved by using the relational model.

In the relational model, all data elements within the data base are logically viewed as being stored in the form of two-dimensional tables called **relations.** These tables are, in effect, flat files in which each row (called a **tuple**) is a record that represents a unique occurrence of an entity. Each column (called a **domain**) represents a field where the record's attributes are stored.

A relational data base can therefore be viewed as a collection of tables in which the relationships among data have been reduced to their simplest forms. The tables serve as the building blocks from which more complex relationships can be created. In other words, updates are accomplished and queries answered by using a DBMS to select or combine data elements from one or more tables. Since the data can be selected and combined in a variety of ways, the relational model provides a very powerful access capability.

Three fundamental operators are used to process the tables:

- ◇ PROJECT selects specified columns from a table to create a new table. Any rows that are exact duplicates of each other are deleted.
- ◇ SELECT creates a new table by selecting rows, or records, that meet specified conditions.
- ◇ JOIN creates a new table by selecting from two or more tables, rows, or columns that meet specified conditions. Join is used frequently, since a single relation often does not contain all the data necessary to satisfy a user inquiry.

Relational data bases are stored on direct access devices using a complex addressing scheme that the user need not be aware of or understand. Physical implementation, which is hidden from the user, often involves indexes, inverted lists, and pointers.

Relational vs. Network Data Bases. Smith and Mufti[1] developed an example that clearly shows the difference between a network-based data base and a relational data base. They used an inventory record to compare a network data base (Fig. 8.22) with a relational data base (Fig. 8.23). The upper-left-hand corner of Fig. 8.22 shows a list of item numbers used to identify various inventory items. For each item, the data base stores data regarding the quantity on hand, the minimum and maximum quantities allowed, and the item classification (lower-left corner). In addition, a list of inventory suppliers is maintained by vendor number (upper-right corner) and is supported by data regarding vendor names, addresses, and telephone numbers (lower-right corner).

Finally, the center of the figure depicts a table of authorized suppliers for each inventory item. The arrows represent but a few of the many relationships between

[1]This example is adapted, with permission, from James F. Smith and Amer Mufti, "Using the Relational Database," *Management Accounting* (October 1985): 43–54.

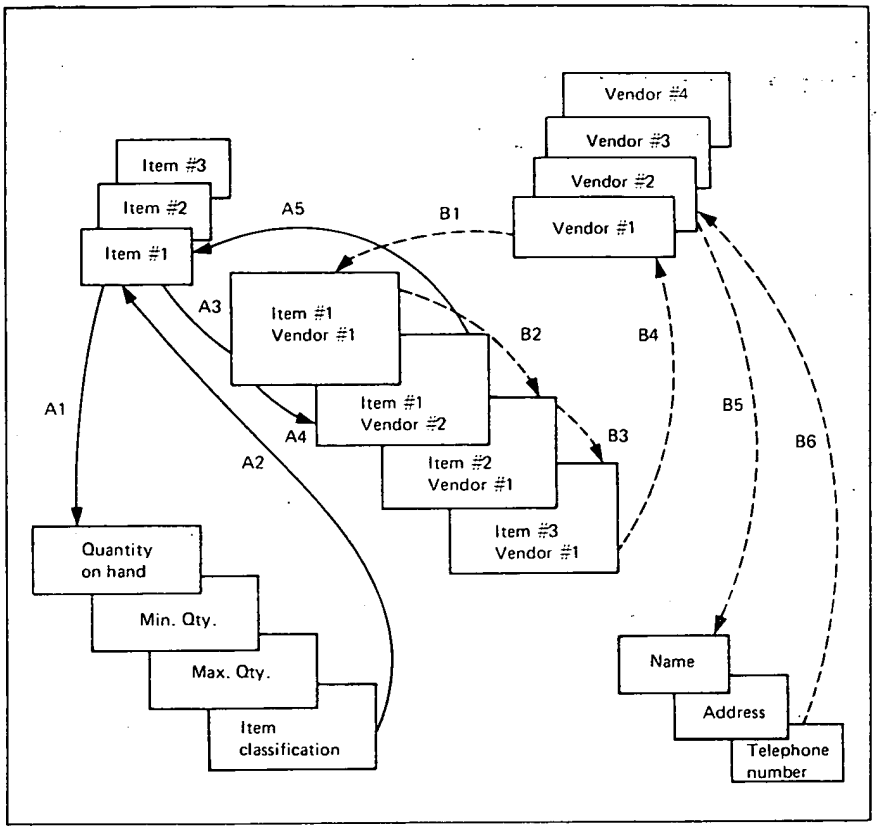


Figure 8.22
Network data base design for inventory record.

the various data. For example, the relationships represented by the solid arrows labeled A1 and A2 would be used by the computer to obtain quantity and classification data for Item #1. Similarly, the computer would use the relationships represented by the solid arrows labeled A3, A4, and A5 to determine which vendors are authorized to supply Item #1, and the relationships represented by the broken arrows labeled B1, B2, B3, and B4 to determine those inventory items that Vendor #1 is authorized to supply.

Figure 8.23 shows the identical inventory record in a relational data base. Notice how the tabular structure of the relational model makes it much easier to understand the nature of the data being stored. In addition, access to the data is facilitated, since the data base can be accessed directly with simpler and more easily understood instructions.

Suppose, for example, that we want to order inventory items classified as B in Fig. 8.23a. To do that, we need a list of the names and addresses of all vendors authorized to supply these items. To generate such a list using either model, we must integrate the separate data files on the inventory items, the vendors, and the authorized vendor table. Performing such an integration using the network

Figure 8.23
Relational data base design for inventory record.

a. Inventory item table

Item number	Quantity on hand	Minimum quantity	Maximum quantity	Item classification
1	310	20	500	B
2	50	10	200	B
3	200	50	400	F

b. Vendor table

Vendor number	Name	Address	Telephone
1	Daxon	33 1st Street	351-8080
2	Alphametics	508 Drapers Road	525-3310
3	Green Ridge	334 Chauncey Place	978-1005
4	Bower Supplies	1995 Main Street	555-1000

c. Authorized vendor table

Item number	Vendor number
1	1
1	2
1	4
2	1
2	4
3	1
3	2
3	3
3	4

model requires considerable programming skills, including proficiency in a computer language such as COBOL. It also requires a knowledge of the relationships contained in the data base, such as those presented in Fig. 8.22. Thus most accountants would require the assistance of a computer specialist.

Generating a printed list of vendors using a relational DBMS, on the other hand, requires only a set of simple, readily understandable instructions such as the following.

```
PRINT ITEM NUMBER FROM INVENTORY ITEM TABLE
AND NAME AND ADDRESS FROM VENDOR TABLE
WHERE ITEM CLASSIFICATION IS B IN INVENTORY ITEM TABLE
```

Once those simple commands have been issued, we need only wait while the data base system: (1) extracts from the Inventory Item Table (Fig. 8.23a) the item numbers for all inventory items having a B classification, (2) uses those item numbers to find in the Authorized Vendor Table (Fig. 8.23c) the vendor numbers for all vendors authorized to supply those items, and (3) uses these vendor numbers to retrieve from the Vendor Table (Fig. 8.23b) all the appropriate vendor names and addresses. Figure 8.24 shows how these data might be presented on a printed report.

Advantages and Disadvantages of the Relational Data Base. From the above example it is apparent that a relational DBMS can provide users with direct, easy, and immediate access to a readily understandable data base. Advocates of the relational data base believe that this approach provides data bases that are easier to work with, more flexible, and more easily modified than any other type of data base. The essence of a well-designed relational data base is that it can provide users with the particular information that they want, when they want it.

Specific advantages and disadvantages of the relational data base model are shown in Fig. 8.25. Since the advantages greatly outweigh the disadvantages for many applications, the relational approach has experienced rapid growth. Given it is the dominant data base approach, accountants should understand the model, how it works, and its advantages and disadvantages.

File and Data Base Design Considerations

When an organization decides to implement a data base, there are a number of important steps that must be taken. Among the most significant are (1) taking

Item number	Vendor name	Address
1	Daxon	33 1st Street
1	Alphametics	508 Drapers Road
1	Bower Electronics	1995 Main Street
2	Daxon	33 1st Street
2	Bower	1995 Main Street

Figure 8.24
Information from DBMS based on a user report.

Figure 8.25
Advantages and disadvantages of the relational data base model.

Advantages of the Relational Data Base Model

- ◇ It often is the most flexible and useful approach for unplanned, ad hoc queries. In a relational data base, access paths are not predetermined; creating new relations simply requires joining tables. In contrast, in a tree or network approach, new connections and access paths must be established if a new relationship is to be added.
- ◇ The DDL and DML are usually simple and user-oriented, and maintenance and physical storage are fairly simple. In contrast, the preestablished relationships of the tree and network structures usually require a more complex DDL and DML, and maintenance often is more difficult.
- ◇ It provides a clear and conceptually simple design and view of complex data relationships but at the same time offers a set of powerful data manipulation capabilities.
- ◇ The data base is very flexible, since each relation within the data base can serve as a point of entry.
- ◇ Data can be easily added, deleted, or modified.
- ◇ Data are maintained in table form, which is more consistent with the human mental process and is very familiar to business-oriented users. This makes the model easier for unsophisticated computer users to master and use.

Disadvantages of the Relational Data Base Model

- ◇ Current relational data bases are often less efficient than a nonrelational DBMS. They can occupy more memory, take longer to update, and be slower in retrieving data. These problems usually make them less effective for high-volume data bases that are infrequently accessed.
- ◇ The indexes used in the relational model, which must be created and maintained along with the records themselves, can be very large and cumbersome.

an inventory of data elements used in the organization; (2) designing schemata for initial data base applications; (3) surveying available DBMS software and selecting the package that best meets the organization's requirements; (4) defining subschemata for specific applications; (5) writing new application programs or modifying existing ones; (6) loading the data into the data base; (7) processing transaction data to update the data base; and (8) maintaining the schemata, subschemata, and application programs. These tasks can be categorized into four different phases: requirements definition, conceptual design, physical design, and implementation and operation.

Requirements Definition

In the first phase, the data requirements, or logical views, of the individual users and applications are determined. There are at least two different types of system requirements: those arising from processing and recording transactions and events, and those arising from users' information needs.

Several different strategies exist for developing system requirements. One is to organize existing applications and files into a data base and then let the data base evolve as new applications are needed and new queries arise. This approach works well for data bases that do not change very much or very often. Another approach is to do a detailed study of the data requirements for all current applications and then combine them to form the data base. A third approach, often

referred to as **conceptual data modeling**, is to try to identify all current and anticipated needs. This approach is based on the argument that data and the relationships between them are the foundation of an information system. It calls for developing a conceptual model of an organization and its components (people, resources, events). By modeling all entities within the organization and the relationships between those entities, one determines present and future data requirements. A data base built on this model will then meet an organization's information needs as long as users do not change the way they view the data entities and the relationships between those entities.

No matter which approach is used, the end result should be a listing of the data that are required in an organization's data base. Determining data requirements is covered in greater depth in Chapter 10.

Conceptual Design

In designing a data base system, certain data base design objectives should be kept in mind. These objectives are summarized in Fig. 8.26. Unfortunately, all of these objectives cannot be maximized. As in all areas of systems design, certain trade-offs are required. For example, cost-effectiveness is usually at odds with other objectives like flexibility, efficiency, accessibility, integrity, and security.

Figure 8.26
Data base design objectives.

Completeness	The data base should contain all the data (and the relationships between the data) needed by its various users. There should be proper integration and coordination of all users and suppliers of data. The data contained in the data base should be recorded in the data dictionary.
Relevance	Only relevant and useful data should be captured and stored.
Accessibility	Stored data should be accessible to all authorized users on a timely basis.
Up-to-Dateness	Stored data should be kept current and up-to-date.
Flexibility	The data base should be flexible enough that a wide variety of users can satisfy their information needs.
Efficiency	Data storage should be accomplished as efficiently as possible. As few resources as possible should be used to store the data. Data base update, retrieval, and maintenance time should be minimized.
Cost-Effectiveness	Data should be stored in such a way that desired system benefits can be achieved at the lowest possible cost.
Integrity	The data base should be free from errors and irregularities.
Security	The data base should be protected from loss, destruction, and unauthorized access. Backup and recovery procedures should be in place so that the data base can be reconstructed if necessary.

The key is to achieve the best possible trade-off so that each objective is maximized, given the restraints imposed by the other objectives.

Designing Network and Tree Data Base Schemata. A critical step in implementing a data base is the design of data base schemata. Most organizations use separate data bases for major functional areas, rather than a single comprehensive data base for the entire organization. Thus the first step in schema design is to determine which data elements to include in which schema. To resolve this problem, it is necessary to identify "clusters" of files and programs that are closely related to each other in terms of processing and usage but are not closely related to files and programs in other clusters.

Once the data elements to be included within a particular schema have been identified, the designer must specify the relationships that exist between them. Those data elements having a one-to-one relationship with each other are candidates for inclusion within the same record. Each entity within a schema may be related to one or more other entities, and each relationship may be either one-to-many or many-to-many. All relationships that are relevant, either to the processing of transactions against the data base or to the retrieval of information from the data base in response to specific user needs, should be explicitly recognized in the data base schema.

Another important aspect of schema design is designating which data elements will serve as keys. The appropriate primary key for each record is generally obvious. The careful selection of secondary keys, however, is significant, because it can enhance data base processing efficiency and facilitate information retrieval. The most appropriate secondary keys generally are those data elements that identify certain properties held in common by groups of records. Examples include invoice due date, employee department number, and inventory location code.

An important objective in the design of a data base schema is simplifying the data structure. The more complicated data structures such as networks (especially complex networks) are more difficult for DBMS software packages to work with than are simpler data structures such as trees and flat files. In fact, the schema definition techniques used by some DBMS software packages do not allow network data structures to be specified explicitly.

By introducing limited redundancy into a data base schema, one can represent a network data structure as a series of tree structures. Consider the network structure in Fig. 8.21. As shown in Fig. 8.27, this complex network can be represented by four tree structures. Although there is redundancy in the record types appearing in this schema, this does not necessarily mean that there will be redundancy in the physical data stored in this data base—the links shown in Fig. 8.27 can be represented by pointers.

Designing Relational Data Bases. Many data base specialists feel that it is desirable to simplify schemata further by reducing all data base files to two-dimensional tables, or flat files. As explained earlier, this type of data base is called a relational data base. Any type of data base structure can be reduced to

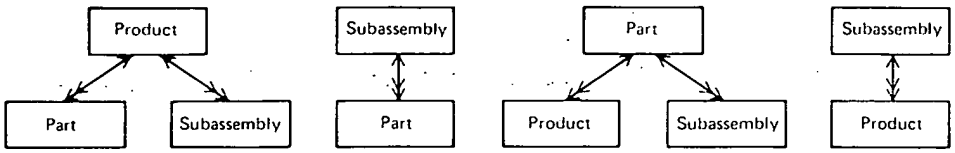


Figure 8.27
Representation of a network data structure by means of a series of tree structures.

a relational form. Figure 8.28 shows the tree data structure from Fig. 8.19 converted to relational form.[2] Notice that each of the three relations represented by arrows in Fig. 8.19 is represented in Fig. 8.28 by pairs of data elements that are contained within the same record. For example, the link between customer and invoice records is established in Fig. 8.28 by including both the customer number and the invoice number within the invoice records.

A complete explanation of how to design relational data bases is beyond the scope of this text. However, two important guidelines will be presented here to provide a background in relational data base design.[3] The first guideline is that

Figure 8.28
A relational data base.

Record type	*Record content*				
Customer	Customer number	Customer name	Customer address	Credit rating	Account balance
Customer transaction	Customer number	Transaction type code	Transaction date	Transaction amount	
Invoice	Invoice number	Customer number	Invoice date	Invoice total	
Invoice line item	Invoice number	Item code	Quantity sold	Line total	
Inventory item	Item code	Item description	Item price		

[2]The process of converting a conventional data base to relational form is beyond the scope of this book. A good treatment of this topic may be found in James Martin, *Computer Data-Base Organization*, 2d ed. (Englewood Cliffs, N.J.: Prentice-Hall, 1977), Chapters 13 and 14.

[3]These guidelines and the examples are adapted from Smith and Mufti, "Using a Relational Database."

a separate data table should be used for each conceptual relationship of interest. That is, no table should incorporate more than one conceptual relationship. In Fig. 8.23a, for example, the Inventory Item Table contains only information about inventory items—the quantity on hand, the minimum and maximum quantities, and the classification of each inventory item. Similarly, the Vendor Table (Fig. 8.23b) contains only information relating specifically to each vendor (i.e., name, address, and telephone number), organized by vendor number.

If these two tables were combined, as shown in Fig. 8.29, the resulting table would contain information regarding two separate objects of interest: inventory items and vendors. Use of this combined table would result in data redundancy. Note in Fig. 8.29 that Item Number 3 has to be stored four times, since there are four vendors for that item. Likewise, Vendor Number 1 has to be stored more than once, since it supplies more than one item. Because each vendor may supply hundreds or even thousands of inventory items, this redundancy could cause file maintenance to be unnecessarily time-consuming and highly susceptible to errors.

A second weakness of the combined table is that vendor data are not maintained independently of inventory item data. If, for example, a vendor is not currently supplying any inventory items to the firm, its name, address, and telephone number will not be included in the data base even though we may wish to maintain this vendor information for future reference.

A second guideline is that each table should be designed so that every row is unique. This can be accomplished by ensuring that at least one column or combination of columns, referred to as the **table key**, contains a different value for each row. For example, the key to Fig. 8.23a is the Item Number column. In this instance, each item number, which uniquely identifies each item of inventory, also uniquely identifies a row in the table. Thus each row contains information pertaining to a specific item of inventory. In Fig. 8.23c, there is no single column that contains unique row values. In this instance the two columns, taken together, constitute a key. That is, the combination of values in the two columns, which uniquely identifies a relationship between inventory items and vendors authorized to supply those items, also uniquely identifies each row.

The accountant should play a key role in the design of data base schemata. The accountant's familiarity with record content and data relationships endows him or her with the perspective necessary to ensure that schema designs adequately satisfy all user requirements. It is also important that other management personnel be involved in the design of those schemata that relate specifically to their areas of responsibility.

Physical Design and Implementation

Physical design consists of taking the conceptual design and converting it into physical storage structures. Physical data base design is seldom of concern to accountants and is therefore beyond the scope of this book.

The implementation phase consists of converting the current system to the data base approach and getting it up and running properly. Implementation concerns are covered in Chapter 12.

INVENTORY TABLE

Item Number	Quantity on Hand	Minimum Quantity	Maximum Quantity	Item Classification	Vendor Number	Vendor Name	Vendor Address	Telephone
1	310	20	500	B	1	Daxon	33 1st Street	351-8080
1	310	20	500	B	2	Alphametics	508 Drapers Road	525-3310
1	310	20	500	B	4	Bower Supplies	1995 Main St.	555-1000
2	50	10	200	B	1	Daxon	33 1st Street	351-8080
2	50	10	200	B	4	Bower Supplies	1995 Main St.	555-1000
3	200	50	400	F	1	Daxon	33 1st Street	351-8080
3	200	50	400	F	2	Alphametics	508 Drapers Road	525-3310
3	200	50	400	F	3	Green Ridge	334 Chauncey Pl.	978-1005
3	200	50	400	F	4	Bower Supplies	1995 Main St.	555-1000

Figure 8.29
Data table containing two distinct concepts.

Impact of Data Base Systems on Accounting

Within many large organizations accounting data are now stored in data base systems. This has some interesting implications for accounting. One of these—the need for accountants to be involved in the process of designing and implementing data base systems—has already been examined. At the organizational level, another significant issue is the impact of data base systems on internal control. The centralization of data storage and integration of data processing brought about by data base systems require that emphasis be placed on matters such as the accuracy of input data, the preservation of audit trails, the control of access to the data, and the maintenance of backup copies of data files. In essence, the organization's data base is an asset that must be safeguarded just like cash, inventories, and equipment.

At a more general level, data base technology may have a profound impact on the fundamental nature of accounting. For example, the accounting process traditionally begins with recording transactions from source documents onto journals. This step is followed by posting from the journals to ledgers, balancing ledger accounts, and ultimately generating financial statements. If the accounting system is converted to a data base, all the accountant needs to do is enter source document data into the data base. Because of predefined data linkages within the accounting data base, the posting and balancing steps are accomplished automatically and immediately as the source data are entered. Financial statements and other accounting reports may then be generated at any time in response to a user request.

Even more important, data base technology could conceivably lead to the abandonment of the double entry accounting model. The basic rationale for the double entry model is the use of redundancy to provide a check on the accuracy of data processing. Every transaction generates equal debit and credit entries, and the equality of debits and credits is checked and rechecked at numerous points in the accounting process. Data redundancy, however, is the antithesis of the data base concept. If the amounts associated with a transaction are entered into a data base system correctly, it is necessary to store them only once, not twice. Computer data processing is sufficiently accurate to make the elaborate system of checks and double checks, which characterizes the double entry accounting model, unnecessary. Thus data base technology could possibly do away with the need for the double entry model. This has not happened yet because alternative accounting models that are more consistent with data base concepts are not widely used. Furthermore, the double entry model is so firmly entrenched in accounting that it may never change—rather, it may just be implemented on data base systems with little or no modification, in spite of the apparent inconsistencies.

Summary

There are two principal approaches to data storage: file-oriented and data base. The file-oriented approach works well in many situations but has a number of significant disadvantages, including data redundancy, lack of data independence,

and inability to satisfy many types of information requests. The data base approach overcomes many of these disadvantages.

In the data base approach, there are two data views: logical and physical. The logical view is how users perceive the data to be organized. The physical view is how data are actually stored on disks or tapes. The separation of the two views, called data independence, is one of the reasons why data base technology is so powerful.

The data base management system is a sophisticated software program that handles translation between the two data views. It consists of a number of different languages, including data definition, data manipulation, and data query languages. There are three types of DBMS users: data base administrators, applications programmers, and users. Data elements stored in the data base are recorded in a data dictionary.

File organization and access methods include sequential, random, hashed, indexed, linked list, and inverted list file organization. Data base organization and access methods include the flat file, tree, network, and relational structure. The relational data base is regarded as the easiest to understand.

Data base design consists of four phases: requirements definition, conceptual design, physical design, and implementation. This chapter discusses the first two phases, and Chapter 12 discusses the last phase. The third, physical design, is typically of little concern to accountants. Since accountants are among the individuals most familiar with their organization's data, they should assume a significant role in data base design. To fulfill that role, they must understand and be able to apply the concepts explained in this chapter.

REVIEW QUESTIONS

1. Define the following terms.

relationship
character
data values
fixed-length records
variable-length records
file
file-oriented approach
data base approach
data base
data base management system
data base system
data base administrator
data independence
data redundancy
logical view
schema
subschema (user view)
physical view
data definition language
data manipulation language
data query language
report writer
applications programmers
ad hoc users
data dictionary
file organization
sequential file organization
direct file organization
file access
direct addressing
hashing (randomizing)
synonyms
index file
indexed-sequential access method
linked list
chain
pointers
inverted file
logical data structures (models)
flat file
tree
nodes
root
parent
children
one-to-many
repeating group
network
many-to-many
simple network
complex network
relational data base
relations
tuple
domain
conceptual data modeling
table key

Chapter 20

The Finance Cycle: Cash Receipts and Disbursements, Capital Assets, and Financial Statements

Learning Objectives

After studying this chapter, you should be able to:

- ◇ Describe the key activities and data processing operations included in the finance cycle.
- ◇ Describe the decision responsibilities and information requirements of financial management.
- ◇ Give several examples of the information provided to financial management by the accounting information system.
- ◇ Flowchart data and information flows within manual and computer-based financial data processing systems.
- ◇ Evaluate and recommend control policies and procedures for a financial data processing system.

Chapter Outline

The **finance cycle** is a recurring set of management activities and related data processing operations directed at securing a steady flow of capital funds into and through an organization. The management activities include arranging sources of capital funds for the organization, maintaining relationships with investors and creditors, planning capital expenditures, establishing credit and collection policies, securing appropriate insurance coverage, planning and controlling cash flows, and evaluating the financial performance of managers, divisions, investments, and so forth. Related data processing operations include managing the receipt and disbursement of cash, maintaining accounting records, and preparing budgets, financial performance reports, and financial statements.

The focus of this chapter is on financial information systems. Financial information is any information concerning the flow of dollars through an organization. Virtually all activities and decisions within an organization have some effect on the organization's finances. The financial management function and the related systems that generate financial information are thus vital to effective business management. This chapter describes the decision responsibilities and information requirements of the financial management function, as well as manual and computer-based information systems for processing cash receipts, cash disbursements, fixed asset records, and general accounting records.

The Financial Management Function

The financial management function encompasses both the **treasurership,** or administration of the finance function, and the **controllership,** or administration of the accounting function. In many business organizations, the treasurership and the controllership are combined organizationally under the authority of a top financial executive, often called the **Chief Financial Officer** (CFO) or Executive Vice-President for Finance. An organization structure of this type is illustrated in Fig. 20.1. As this chart indicates, it is common for the Director of Internal Auditing to also report to the CFO; this structure is consistent with the need for the internal audit function to be organizationally independent of the accounting function.

Internal auditing, the controllership, and other accounting functions were discussed in Chapter 2 and elsewhere throughout this book. Therefore this section concentrates on the Chief Financial Officer, the Treasurer, and the various staff functions reporting to the Treasurer. Each of these is discussed in turn.

The Chief Financial Officer

The Chief Financial Officer is responsible both for administering the functions under his or her authority and for making decisions and recommendations about the most important aspects of the finance function. Into the latter category fall decisions concerning long-term financing, dividend policy, capital investments, short-term management of cash flows, and allocation of resources within the enterprise.

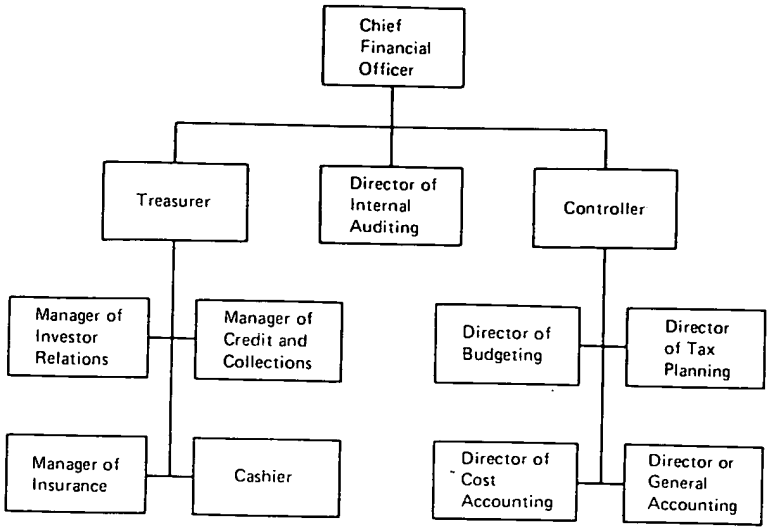


Figure 20.1 *Organization structure for financial management.*

Decisions about long-term financing are generally made very infrequently in most business organizations, perhaps only once every few years. Each major decision in this area, however, will have a significant impact on the firm's success and growth over an extended period of time. The two most crucial aspects of the long-term financing decision are timing and sources. Planning the timing of financing involves determining when entry into the capital markets can be achieved on terms most favorable to the firm. Selecting the sources of long-term financing involves choosing among such alternatives as bonds, common stock, preferred stock, and other financial instruments. Dividend policy is also closely related to long-term financing, because another source of long-term funds is retained earnings that are not paid out as dividends.

Much of the information required for decisions on long-term financing is external information concerning, for example, the state of the economy and its impact on stock and bond prices, interest rates, and the capital markets generally. Internally generated information useful for decision making in this area includes long-term past and future information regarding the firm's financial position and earnings performance. Basic financial statements generated by the accounting function, such as the balance sheet and income statement, provide a perspective on past trends and present conditions. Major plans developed by top executives, and the financial projections generated on the basis of such plans, are also an important source of information.

Planning and control of capital expenditures are other areas of decision making in which the Chief Financial Officer is deeply involved. Planning capital expenditures consists of determining the total size of the capital expenditures budget for the firm each year or quarter and choosing among alternative fixed asset purchases. Controlling capital expenditures involves establishing policies for granting approval of expenditure requests, following up on the execution of the

expenditure and the installation of the asset, and evaluating the actual return on the invested capital relative to the estimated return.

The information required for capital expenditure planning consists primarily of estimates of cash inflows and outflows and of risk factors associated with alternative fixed asset purchases. The discounting technique should be applied to cash flow estimates to derive a net present value for each alternative investment.[1] The availability of funds for capital expenditures may be estimated on the basis of sales forecasts and earnings projections. Information generation for control of capital expenditures begins with the formal request for authorization of the expenditure, which indicates the costs associated with the purchase, the expected benefits, and the projected revenues or cost savings. A record of all vital data relating to the asset should be prepared when the asset is purchased and received, and should be maintained for as long as the asset is owned and used. Other control information may be generated from follow-up studies that evaluate the accuracy of the original cost and revenue estimates.

Planning and control of operating expenditures are other areas of major concern to the Chief Financial Officer. Responsibilities include preparing annual operating budgets for departments and divisions within the organization and establishing systems of control reporting that generate comparisons of actual performance of each department or division with the operating budget. Planning and control of operating expenditures also involve interpreting reported operating performance to provide a basis for managerial decisions and actions.

The Treasurer

The treasurership function is concerned primarily with the management of short-term cash flows and with policy making and administration with respect to the various staff functions under the Treasurer's authority. Cash management involves making decisions about the investment of cash balances in excess of short-term cash requirements and about the timing and sources of short-term cash borrowing. Alternatives for short-term cash investment include United States Treasury bills, bank certificates of deposit, and commercial paper. Alternative sources of short-term borrowing include trade credit, commercial bank unsecured credit, and secured loans using inventories or accounts receivable as collateral.

Effective short-term cash management requires both external and internal information. Decisions on investing idle cash should be based on information on the nature, yield, and maturity dates of various alternative investments. Decisions on short-term borrowing should take into account information relating to sources of supply. The timing decision depends primarily on internal information concerning when excess cash balances will be available or when short-term borrowing will be required. Short-term cash budgets that project weekly or monthly cash flows for the immediate future are one source of such information. These budgets

[1]For an extensive treatment of capital budgeting and cash flow discounting, see Harold Bierman, Jr., and Seymour Smidt, *The Capital Budgeting Decision*, 7th ed. (New York: Macmillan, 1988).

may be supplemented by revenue projections generated from accounts receivable data and by cash outflow projections generated from accounts payable and purchase commitments data.

Manager of Investor Relations

The Manager of Investor Relations is responsible for developing and maintaining a satisfactory market for the firm's securities. The manager must communicate with stockholders; with security analysts, who advise investors; with stock exchanges, through which securities are traded; with investment bankers, through whom new securities are issued; and with the Securities and Exchange Commission, which regulates the securities markets. The information requirements of this position are primarily external. The stockholder record-keeping system provides some information of use to the Investor Relations Manager, such as reports on the holdings and dealings of the company's largest shareholders. In addition, much company information is funneled through the Investor Relations Manager and reported to stockholders, security analysts, and others interested in the company's activities.

Manager of Credit and Collections

The Manager of Credit and Collections is responsible for developing and administering policies on the granting of credit and collection of accounts. Credit granting policies, credit limits, and collection procedures must be tight enough to avoid unnecessarily tying up in accounts receivable funds that could be profitably invested elsewhere. On the other hand, such policies and procedures must be loose enough to avoid the loss of sales and customers. The Manager of Credit and Collections must find the optimal trade-off between these two objectives.

Some of the information requirements of the credit and collection function are external. For example, the manager needs information on the creditworthiness of new customers in order to decide whether, and to what limit, to extend credit to them. Primary external sources of credit information include Dun & Bradstreet, which provides credit reports and ratings on business firms, and local credit bureaus, which provide credit reports on individuals. Much internal information should also be available to assist in credit decisions. Records of the payment history of a customer are useful in making decisions on whether to extend further credit. Records of current past-due balances are also relevant to the credit granting decision and to the decision as to whether to initiate special collection procedures. Reports analyzing customer accounts written off as uncollectible are constructive in the establishment of credit granting policies.

Manager of Insurance

The Manager of Insurance is responsible for identifying and evaluating potential losses to the firm that are insurable, selecting the appropriate mix of insurance

coverage and other methods for dealing with the potential losses, obtaining insurance coverage on terms favorable to the firm, and administering the firm's various insurance contracts. This function is sometimes referred to as the risk management function. The Manager of Insurance needs both external and internal information for decision making. External information requirements include knowledge of the characteristics and costs of various types of available insurance coverage. Internal information requirements include estimates of potential losses that would result from physical damage to assets, disability or death of key employees, criminal action, and fraud or negligence on the part of employees. In the case of physical damage to assets, accounting records provide some useful information. In the case of the other types of losses, however, accurate measures of the size and likelihood of potential losses may be hard to develop from available information. In order to administer the organization's insurance programs, the Insurance Manager needs information concerning payment of premiums, execution of new insurance contracts in accordance with established policies, maintenance and funding of reserves for self-insurance, and reporting and collection of claims.

Cashier

The function of cashier is primarily administrative rather than policy-making or decision-making. The Cashier is responsible for endorsing, depositing, and maintaining a record of cash receipts; reviewing disbursement authorizations; signing and distributing checks; and maintaining a record of cash disbursements. Also included in this function is the maintenance of banking arrangements for the organization.

The Financial Data Processing System

This section reviews the basic accounting transactions that reflect financial data processing operations, describes the data content and structure of the financial accounting data base, discusses the operations of a number of manual systems for financial data processing, and explains the internal control objectives and procedures associated with financial data processing systems. Systems for processing data on cash receipts, cash disbursements, fixed assets, and the general ledger are described. The systems described are not those of any real organization, but are representative of financial data processing systems in general.

The Accounting Transactions

Numerous accounting transactions summarize the processing of data from which accounting information for financial management is generated. The most significant of these are reviewed here.

Cash Receipts and Disbursements. The primary accounting journal entry with respect to cash receipts is as follows.

Cash	XXX	
Accounts Receivable		XXX

In retail companies many sales are for cash rather than on account. These transactions are reflected by the following entry.

Cash	XXX	
Sales		XXX

These summary entries are typically made daily for the complete batch of cash receipts processed during the day. Other miscellaneous accounts that are less regular sources of cash receipts include notes receivable, sales of fixed assets, and miscellaneous income from dividends, interest, or rentals.

The primary cash disbursement transactions are reflected by the following journal entry.

Accounts Payable	XXX	
Cash		XXX

This entry is also generally made each day, to summarize the preparation and distribution of a batch of checks. Credits to accounts payable originate from purchases of inventory and fixed assets and from the incurrence of costs and expenses.

Another cash disbursement transaction reflecting a high volume of individual transactions appears thus.

Wages and Salaries Payable	XXX	
Cash		XXX

The liability account is originated each time the payroll is processed; it represents the difference between gross pay and all deductions. The entry itself reflects the distribution of paychecks to employees.

A third cash disbursement entry, which represents the most regularly recurring transaction with stockholders, follows.

Dividends Payable	XXX	
Cash		XXX

The liability account itself is originated by debiting the retained earnings account. This transaction is generally executed quarterly, and the entry summarizes the distribution of a batch of dividend checks to all stockholders. Most corporations have a bank act as transfer agent, administering records of share transfers among stockholders. Many firms have their transfer agent process dividend payments as well. Systems for administering capital stock records are not discussed further in this chapter.

Cost and Expense Distribution. Various accounting processes culminate in the recording of costs and expenses. A composite entry reflecting several of the most significant of these processes follows.

Manufacturing Overhead	XXX	
Selling Expense	XXX	
General and Administrative Expense	XXX	
Accounts Payable		XXX
Payroll		XXX
Accumulated Depreciation		XXX
Supplies Inventory		XXX
Accrued Expenses Payable		XXX
Allowance for Bad Debts		XXX

The accounts debited in the above composite entry are control accounts, each of which encompasses a large number of subsidiary cost and expense accounts. Examples of the subsidiary accounts include wages and salaries expense, depreciation, insurance, taxes, utilities, advertising, supplies, travel, and bad debts. These debits arise from several processes. Perhaps the primary source is the debit distribution generated from the daily preparation of disbursement vouchers, which establish and authorize payment of accounts payable. The debit distribution shows how the total credit to accounts payable is apportioned to various debit accounts. The payroll entry is made as payrolls are processed, generally weekly or monthly. The debit to supplies expense and the credit to supplies inventory are made as supplies requisitions are processed but are subject to adjustment when periodic inventories of supplies are taken. The depreciation and accrual portions of the entry, including the estimate of bad debts expense, are generally made at the end of each month.

Fixed Assets. The recording of fixed asset acquisitions is reflected by the following journal entry.

Fixed Assets	XXX	
Accounts Payable		XXX

If the asset is a very large purchase, the credit portion of the entry may be partly recorded to a long-term liability account. Very small asset purchases may simply be expensed for the sake of convenience. This entry generally arises as part of the debit distribution of accounts payable, as described above. The volume of such transactions is usually minimal in relation to that of other debits arising from accounts payable processing.

Financial Statement Preparation. Standard practice in most firms is to prepare balance sheets and income statements monthly. Before this can be done, a variety of **adjusting entries** must be made. These entries include accrual of expenses incurred but not yet paid, such as interest, wages and salaries, and utilities; expiration of prepaid expenses, such as depreciation, insurance, and supplies; accrual of revenue earned but not yet collected; recognition of the earned portion of revenues collected in advance; and other special entries such as adjustment of the inventory accounts to record the results of a physical inventory, or elimination of profits and account balances arising from intercompany transactions. Following the preparation of annual financial statements, a series of

closing entries are made. These reflect the zeroing out of all revenue and expense account balances and the transfer of the net credit or debit (net income or loss) to the retained earnings account.

The Financial Accounting Data Base

The overall structure of the financial accounting data base is illustrated in Fig. 20.2. The key master files in this data base are traditionally referred to as **ledgers**; this term is a carryover from manual systems in which these files are often maintained in bound ledger books. The **general ledger** is a master file in which a record is maintained for each and every account in the organization's accounting system. The key field for the general ledger consists of the account codes that compose the chart of accounts, illustrated in Figs. 3.8, 3.9, and 3.10. A **subsidiary ledger** is a master file of accounting records for a specific category of accounts. The most significant subsidiary ledgers are accounts receivable; inventory including raw materials, work-in-process, and finished goods; fixed assets; accounts payable; manufacturing overhead; selling expenses; and general and administrative expense.

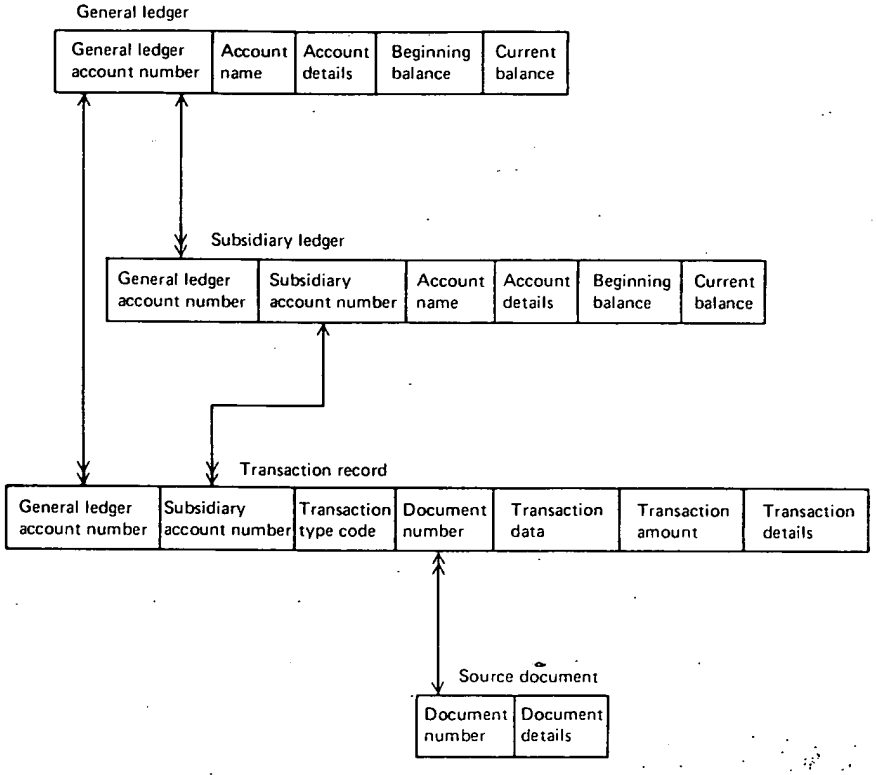


Figure 20.2 *Financial accounting data base.*

The basic format of all ledger accounts is identical, whether they are maintained manually or by computer. Each contains a key field (account number), an account name, an account balance as of the beginning of the current period, and a current account balance. In addition, each contains an itemization of all transactions affecting the account during the current period. Each transaction contains a notation referencing a source document or journal. The classic example of this format is the "T-account," which should be very familiar to all accounting students. In this format, the transaction record is a repeating group within the ledger record, as reflected by the double arrows from the ledger records to the transaction record in Fig. 20.2. Also indicated in Fig. 20.2 is the fact that each source document record may support one or more transaction records.

The relationship between general ledger records and subsidiary ledger records requires that there be a single general ledger control account for each subsidiary ledger. The balance of the control account represents the sum total of the balances of all the accounts in the subsidiary ledger. When a batch of transactions is recorded in a subsidiary ledger, the total amount of all those transactions is simultaneously recorded as a single transaction in the general ledger control account. For some general ledger accounts, such as cash, prepaid expenses, bonds payable, and retained earnings, there is no subsidiary ledger. Therefore, as implied by Fig. 20.2, transaction records affect these accounts directly rather than indirectly through a subsidiary ledger.

Several examples of subsidiary ledgers have been discussed and illustrated in previous chapters. For example, the finished goods inventory file and customer file discussed in Chapter 16 and illustrated in Fig. 16.5 are equivalent to a finished goods inventory ledger and accounts receivable ledger, respectively. The raw materials inventory file and vendor file discussed in Chapter 17 and illustrated in Fig. 17.5 are equivalent to a raw materials inventory ledger and accounts payable ledger, respectively. Note that the data base structure corresponding to all four of those subsidiary ledgers is identical to the general structure shown in Fig. 20.2—that is, each subsidiary ledger record owns a series of transaction records, and each transaction record is related to a source document record. Also note that each subsidiary ledger record format may go beyond the basic format described earlier to contain data fields unique to the particular entity, such as the customer credit rating or the inventory location code.

In manual accounting systems, all transactions are initially recorded in a **journal**, which lists the amounts debited or credited to each ledger account affected by each transaction. There are special journals for high-volume transactions such as cash receipts, cash disbursements, purchases, and sales, as well as a general journal for all other transactions. Another major accounting operation in a manual system is the posting of transactions from journals to ledgers. In an accounting system utilizing data base technology, the procedures for source data entry, journal preparation, and posting are integrated into a single process. As source document data are entered into the system, transaction records are created, and posting is accomplished by linking each transaction record to its corresponding ledger record and then increasing or decreasing the current balance of the ledger record for the transaction amount. Although transaction files are not the same

as journals, a traditional accounting journal may easily be prepared from the transaction records by means of a query language command. For example, to generate a cash receipts journal for October 13, 1989, we could use a command such as "PRINT ALL TRANSACTION RECORDS HAVING TRANSACTION CODE = CR AND DATE = 101389."

In manual accounting systems, ledger records are often maintained on specially formatted cards, such as the materials ledger card illustrated in Fig. 17.6 or the fixed asset ledger card shown in Fig. 20.3. Processing of fixed asset transactions in both manual and computer-based systems is discussed later in this chapter. The basic input transactions include the purchase of new fixed assets, additions to or major repairs on existing assets, and disposal through sale or scrapping of existing assets. Records of accumulated depreciation for each asset are also commonly maintained on the ledger card. The fixed asset ledger is used as a basic reference for general accounting, capital budgeting, insurance administration, and tax planning. Outputs that may be generated from the file of fixed asset ledger records include summary analyses of depreciation or asset cost by type of asset, by department, or by division.

The data content and organization of the manufacturing overhead ledger, the

Figure 20.3
Fixed asset ledger record.

PLANT AND EQUIPMENT HISTORY LEDGER

Kelly Manufacturing Corp. 1234 Fifth St. Albany, NY 12205

Item No. 6648	Serial No. 613440736	Dept. No. 407

DESCRIPTION	MANUFACTURER
IBM 4331 Processor, Model K2 Mainframe Memory-2 megabytes	IBM Corporation Data Processing Division 1133 Westchester Ave. White Plains, NY 10604

COST INFORMATION					RECORD OF IMPROVEMENTS			
Item	Date	Ref.	Amount		Date	Ref.	Amount	
Acquisition	6/30/90	V-1089	$150,000	—				
Transportation In			—					
Installation Cost	6/30/90	V-1274	2,000	—				
Subtotal			$152,000	—				
Estimated Salvage Value			8,000	—				
Depreciable Cost			$144,000	—				

DEPRECIATION RECORD

Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	19__
Rate	25% x ½	25%								
Beginning Balance	$144,000	$125,000								
Annual Depreciation	19,000	33,250								
Adjustments to Depr.	—	—								
Reserve Balance	19,000	52,250								
Net Book Value	133,000	99,750								

selling expense ledger, and the general and administrative expense ledger correspond almost directly to the basic format of all ledger accounts as described above. The beginning balance of all accounts in these ledgers is always zero, because they are closed to the profit and loss summary at the end of each period. Little descriptive information other than an account title is included in these account records. Each transaction subrecord within each subsidiary account contains the transaction date, amount, and disbursement voucher or other source document reference number. The only difference between these ledgers lies in the type of accounts included in each. The manufacturing overhead ledger consists of such accounts as inspection, supervision, maintenance and other indirect labor, small tools, factory utilities, and depreciation on plant and factory equipment. The selling expense ledger is composed of accounts for salaries and commissions of salespeople, salaries of sales supervisors and clerical staff, shipping expenses, depreciation of selling facilities and equipment, supplies, postage, advertising, travel, and so forth. The general and administrative expense ledger includes accounts for executive and clerical salaries, depreciation and rental of office facilities and equipment, supplies, postage, travel, contributions, and income taxes.

The cost and expense ledgers are updated for accounting transactions arising from accounts payable debit distribution; payroll processing; and depreciation, accruals, and other end-of-period adjustments. The most important reports generated from this file are departmental performance reports comparing the actual expenses incurred in each department, obtained from the ledger, with budgeted expenses, and perhaps also with expenses incurred for the same period in the previous year.

The data content and organization of the general ledger also correspond to the universal ledger format described above. The inputs and outputs associated with the general ledger should be familiar to all accounting students. The inputs consist of debit and credit transactions recorded in journals or on journal vouchers (see Fig. 16.4). The primary outputs are the financial statements, including the balance sheet, income statement, and cash flow statement. For internal reporting purposes, financial statements for subsidiaries and divisions are also prepared, and these often include comparisons of current statement information with budgeted amounts.

Most modern organizations use budgeting in financial planning and control. To do so, an organization must have a master file of budget information for each general ledger account, as well as for each cost and expense subsidiary account. There are several possible approaches. For example, budget data could be included within the general ledger records themselves, or they could be contained in a separate budget master file. Each budget record could contain an estimate of the monthly increases and decreases in the account over the budget horizon, or it could contain a formula by which such budget estimates could be computed. A commonly used formula for estimating budgeted costs and expenses is to multiply the variable rate of the cost or expense times the base to which the rate is applied and then add an estimate of the fixed portion of the cost or expense for the period. For example, indirect labor for the assembly department might be

budgeted as $1000 per month (the fixed portion) plus ten cents (the variable rate) per direct labor hour (the rate base). Therefore the budget record for the indirect labor account would contain separate fields for the monthly fixed cost, the variable cost rate, and a code indicating the base to which the variable cost rate is applied.

The budget master file is updated periodically to reflect current information on budget estimates. Many reports for control purposes are generated as output of the budget master file. Reports comparing actual and budgeted expenses by department and division are essential for performance evaluation and feedback to managers. Such reports are prepared monthly, quarterly, and annually. The budget master file may also be used to generate cash flow budgets on a monthly basis.

Manual Systems

This section describes manual data processing systems for cash receipts, cash disbursements, fixed assets, and the general ledger.

Cash Receipts. Figure 20.4 illustrates the process of receiving payments on account for a typical manufacturing company. It is assumed that the company receives most such payments by check through the mail. These are opened in the mail room, where a list of all receipts in a batch is prepared, perhaps in the form of an adding machine tape. All checks are sent to the Cashier's department for endorsement and deposit in the bank. The batch total accumulated in the mail room is used by the Cashier's department as a check on the accuracy of the deposit. On the basis of the deposit, the Cashier's department prepares a journal voucher debiting cash and crediting accounts receivable. This voucher is sent to the general ledger section.

Enclosed with each customer's payment should be a **remittance advice,** which indicates the invoices, statement, or other items on the basis of which the payment is made. If most of its customers are small companies or individuals, a company should request that the customer return one copy of the invoice or statement with the payment, and this then serves as a remittance advice. Remittance advices are separated from checks in the mail room and sent in a batch to accounts receivable, where they are posted to individual accounts. On the completion of the posting process, a new balance of accounts receivable is calculated, and the total change in accounts receivable is determined. This total change is then compared by the general ledger section with the amount of the journal voucher from the Cashier's department. If the two amounts do not agree, an error has occurred that must be discovered and corrected.

An assistant controller or another official in the Accounting department plays an important role in the cash receipts process. This official receives a copy of the batch total of cash receipts from the mail room each day and compares it to the daily bank deposit slip. In addition, this person receives a monthly bank statement, on the basis of which a bank reconciliation is prepared. As part of

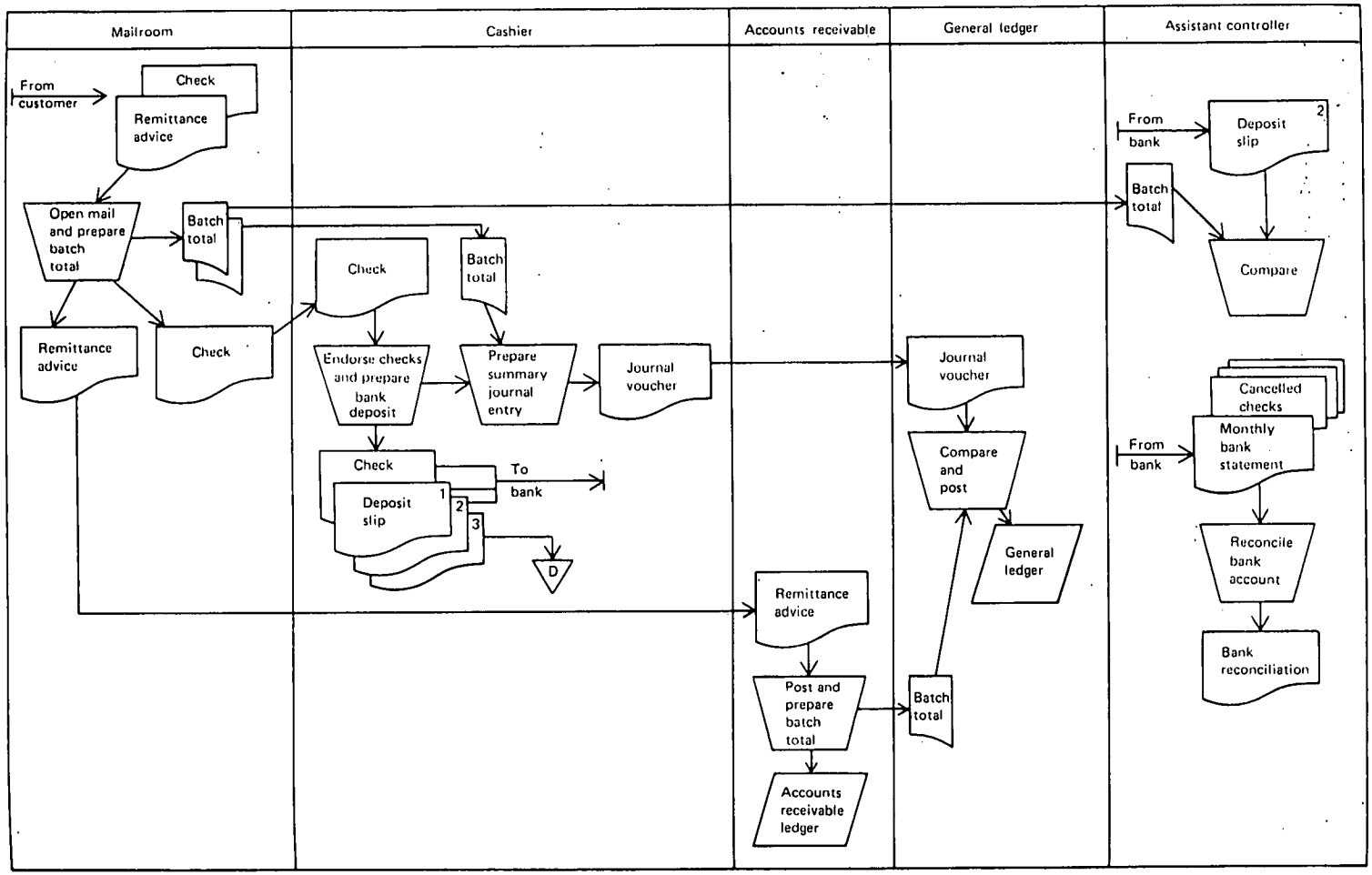


Figure 20.4
Document flow in a manual system for processing cash receipts.

this process, the bank statement listing of deposits should be compared to the corresponding deposit slips. These procedures should reveal any errors or irregularities that occurred after a proper batch total was accumulated in the mail room.

One important activity of the accounts receivable clerk does not appear in the flowchart. The accounts receivable clerk should periodically check the status of all open customer accounts. Any accounts for which payment is significantly past due should be brought to the attention of the Manager of Credit and Collections. This information might be reported in the form of an aging schedule of all past-due accounts. On the basis of this feedback, the Manager of Credit and Collections may decline to provide further credit to these customers and may initiate special collection procedures. In the event that account write-offs become necessary, they should be initiated in the Credit department after all attempts to collect the account have proved unsuccessful. The Credit department would prepare a journal voucher recording the debit to allowance for bad debts and the credit to accounts receivable, for posting by the general ledger clerk. A copy of the write-off authorization would also be sent to the accounts receivable clerk, for posting to the subsidiary ledger account.

Establishing procedures to control sales of merchandise for cash is a major concern of retail enterprises. The most critical point in the process from a control standpoint is the transaction itself. Once the transaction has been properly recorded, a firm basis for control has been established. Two procedures are most useful in securing control at the point of the transaction itself. One is the use of cash registers, whose control features include a display window in which the amount rung for a sale is shown, a provision for issuing a receipt for each sale to the appropriate customer, and a locked-in paper tape record of each transaction. The second critical control procedure is close supervision of personnel.

Many organizations use a form of internal check to control the cash sales process subsequent to the recording of the sale. Sales slips are prepared at the point of sale, and at the end of each day they are processed in a batch to update sales records. A batch total of cash sales is obtained from this process. Also at the end of each day, cash from each register is collected, and cash register tapes are used as a basis for preparing a deposit slip and a journal voucher to record the debit to cash and the credit to sales. The totals obtained from these two processes are then reconciled, with adjustments made for credit sales, payments by check, sales returns, and like factors. If a discrepancy exists, steps can be taken to discover and correct the error.

Cash Disbursements. A document flowchart of a manual system for processing cash disbursements is illustrated in Fig. 20.5. The Accounts Payable department maintains a file of invoices approved for payment, by due date of the invoice. For inventory purchases, approval of invoices for payment is made by the Accounts Payable department on the basis of purchase orders and receiving reports. For costs and expenses and fixed asset purchases, payment authorization may consist of the signature on the invoice of the department head to whose department the cost, expense, or asset is to be charged. For each invoice, or each

Document flow in a manual system for processing cash receipts.

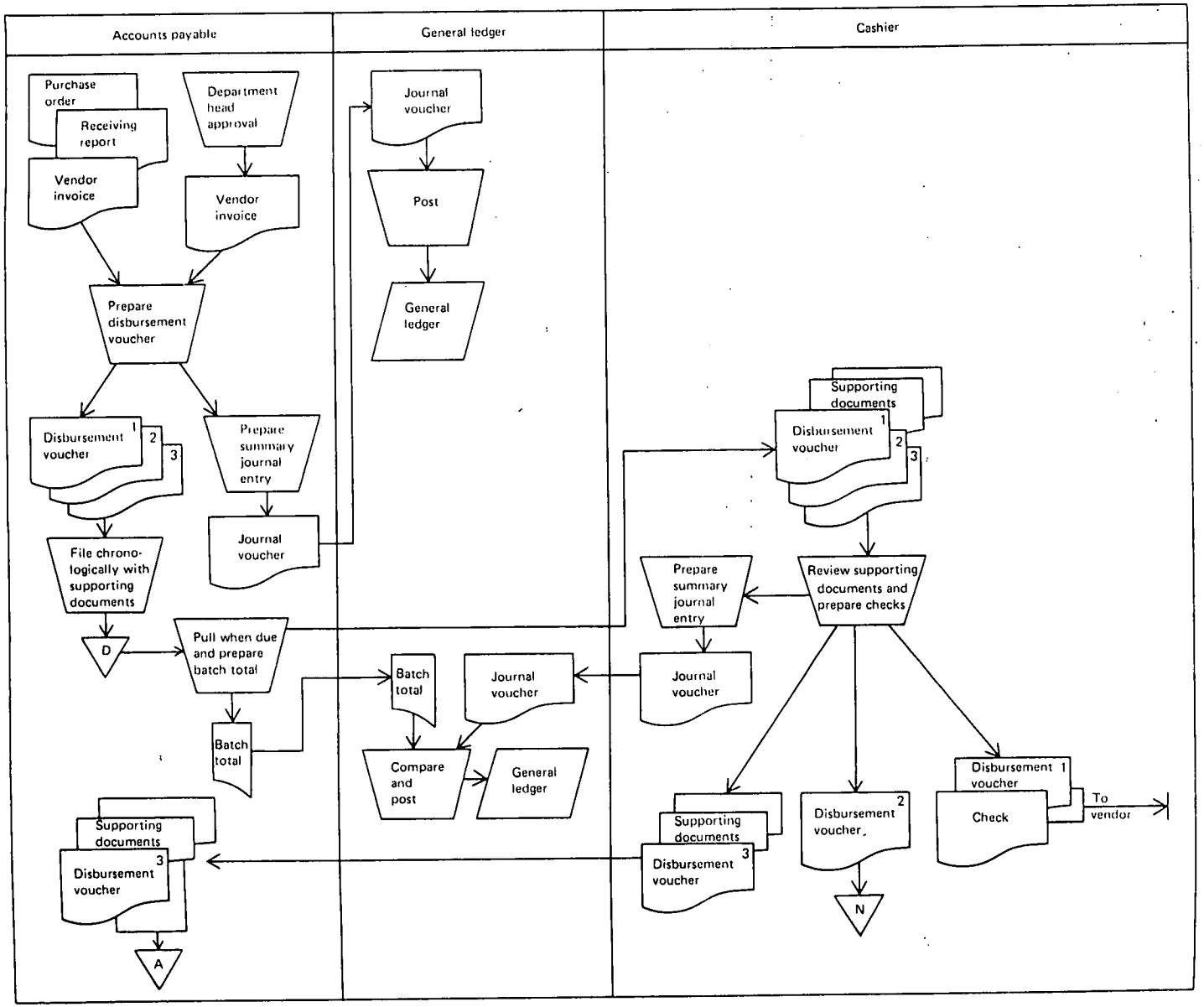


Figure 20.5 *Document flow in a manual system for processing cash disbursements.*

set of invoices from one vendor, that has been approved for payment, a **disbursement voucher** is prepared. The disbursement voucher, illustrated in Fig. 20.6, is simply an authorization to pay a vendor for the invoices and amounts shown on the voucher.

Three copies of each disbursement voucher are prepared for each approved invoice and filed by due date together with all supporting documents. For each voucher, the Accounts Payable department prepares a **debit distribution;** this list details the accounts to which all debits arising from recognition of accounts payable are charged. After the processing of each day's batch of vouchers has been completed, the Accounts Payable department prepares a journal voucher summarizing the debit distribution and indicating the total credit to accounts payable. The journal voucher is provided to the general ledger clerk for posting to the general ledger and the cost and expense subsidiary ledgers.

Each day the file of vouchers payable on that day is pulled. A batch total of the net amount to be remitted is prepared, and the disbursement vouchers and all supporting documents are provided to the Cashier. The supporting documentation for each voucher is reviewed by the Cashier, who then prepares and signs a check in payment of the voucher. For control purposes, a second person, perhaps the Treasurer, may also review supporting documents and countersign each check. All supporting documents should be stamped paid or otherwise clearly marked to preclude their reuse to authorize disbursements. The checks are then

Figure 20.6
Disbursement voucher.

THE NEEDMORE MANUFACTURING COMPANY
123 Elm Street, Needmore, Texas 78989

Voucher No. 1623

Date entered: 11/17/89
Prepared by: *B. Webster*
Vendor Number: 65432
Remit to:
Avalon Electronics
401 Cherry Street
Waco, Texas 78123

Debit Distribution	
Acct. No.	Amount
00-610	$ 996.75
21-632	$ 308.15
23-632	$ 192.44

Your invoice Number	Your invoice Date	Invoice Amount	Returns & Allowances	Purchase Discount	Net Remittance
5386	11/01/89	$ 984.50	$ 98.45	$ 17.72	$ 868.33
5467	11/03/89	$ 641.85	$ 0.00	$ 12.84	$ 629.01
VOUCHER TOTALS:		$ 1626.35	$ 98.45	$ 30.56	$ 1497.34

mailed out, together with a copy of the voucher, which serves as a remittance advice. A second copy of the disbursement voucher is filed by voucher number. The supporting documents, including the vendor invoice and, where applicable, the receiving report and purchase order, are attached to the other copy of the disbursement voucher and returned to the Accounts Payable department for filing in the alphabetical vendor file. For each daily batch of checks, the Cashier also prepares a journal voucher that reflects the debit to accounts payable and the credit to cash, and this voucher is transmitted to the general ledger clerk. This journal voucher is checked against the batch total prepared by the Accounts Payable department and is then posted to the general ledger.

The preparation of the bank reconciliation by an assistant controller (see Fig. 20.4) provides a final control check on the cash disbursements process. All canceled checks should be examined to ascertain the date of endorsement and name of endorser. All checks paid should be accounted for as either canceled, outstanding, or voided. For this purpose, of course, checks must be sequentially prenumbered.

Many firms find it convenient to be able to make some small cash disbursements in cash rather than by check. In such cases, a petty cash fund may be established from which such disbursements can be made. Use of an imprest system for maintaining such funds provides control over the cash disbursed in this manner. Under this system, the amount of the fund is set at some specified amount, such as $100. A petty cash fund custodian is made solely responsible for the fund; this person should not have any other cash handling or recording functions. The appointed individual must prepare a petty cash voucher for each disbursement made from the fund and obtain the signature of the payee on the voucher. The fund custodian retains these vouchers so that at any given time the total amount of the vouchers plus the cash remaining in the fund should equal the total amount of the fund. An internal auditor may periodically make surprise counts of the fund to verify this condition.

When the amount of the petty cash fund is low, the fund custodian presents all petty cash vouchers to the Accounts Payable department. On the basis of these supporting documents, a disbursement voucher is prepared authorizing replenishment of the fund in the exact amount of the total of all the petty cash vouchers. The Cashier then prepares and signs a check from this disbursement voucher to accomplish the replenishment. Petty cash vouchers must be marked paid at this time to prevent their reuse. Furthermore, the cashier should verify the unexpended balance of the fund at this time. The replenishment check should bring the fund balance up to its specified maximum level.

Fixed Assets. The primary procedures and controls connected with accounting for fixed assets relate to the maintenance of the fixed asset ledger and the acquisition of new assets. The paid disbursement vouchers and their supporting documentation serve as source documents for the origination of asset records in the fixed asset ledger. This ledger is used for preparing and recording depreciation. It may also be used to record appraisals for insurance purposes.

Control over the fixed assets themselves requires that the serial number and

location of each asset be recorded in the fixed asset ledger. All transfers of an asset from one location to another should be authorized and documented, with the resulting documentation serving as a basis for recording such transfers in the fixed asset ledger. Periodically an inventory of fixed assets should be taken and the asset ledger adjusted if necessary. Reconciliation of the asset ledger with the fixed asset control account from time to time is also a necessary control procedure.

For control of fixed assets it is also essential that retirements of fixed assets be approved by a specified individual, and that a system exist to ensure prompt and accurate recording of such retirements. The journal voucher recording a sale or scrapping of an asset must be prepared with reference to the asset ledger, to ensure proper recording of the gain or loss as well as removal of the cost and accumulated depreciation from the books.

Control procedures for fixed asset acquisition are essential. Each asset purchase should be authorized by a designated manager after review of a request form that delineates the cost factors associated with the asset and the reasons for its purchase. Many firms utilize a system whereby asset purchases involving small amounts may be approved by lower level managers, such as the General Supervisor or Director of Sales, from their departmental capital expenditure budgets. Larger purchases require approval at higher levels, and very large purchases require the approval of the President and board of directors. Formal capital budgeting analysis, including cash flow projections and discounted present value calculations, should accompany these large proposals. Follow-up reports should be prepared on large projects to evaluate whether the expected results were actually achieved.

General Ledger. A general ledger function has been included in most of the document flowcharts of manual data processing systems presented in Chapters 16 through 20 (see, for example, Figs. 20.4 and 20.5). These flowcharts have shown that one of the primary tasks performed by the general ledger function is the posting of journal entries to the general ledger. Also important are month-end procedures that culminate in the preparation of company financial statements. Figure 20.7 is a systems flowchart illustrating the nature of manual procedures for maintaining the general ledger and preparing monthly financial statements.

As the flowchart indicates, the general ledger function regularly receives journal vouchers or other documentation of accounting journal entries. These are used as a basis for posting to, or updating the accounts in, the general ledger. This posting process may be done daily, weekly, or monthly, depending on the volume of entries. At the end of the month, each general ledger account is balanced, and all account balances are listed on a trial balance. The sum of all debit account balances on the trial balance must be equal to the sum of all credit balances. If the two are not equal, an error has occurred either in posting or balancing the accounts or in preparing the trial balance. Any such errors must be found and corrected. This monthly balancing step provides an important internal check on the overall accuracy of the accounting process.

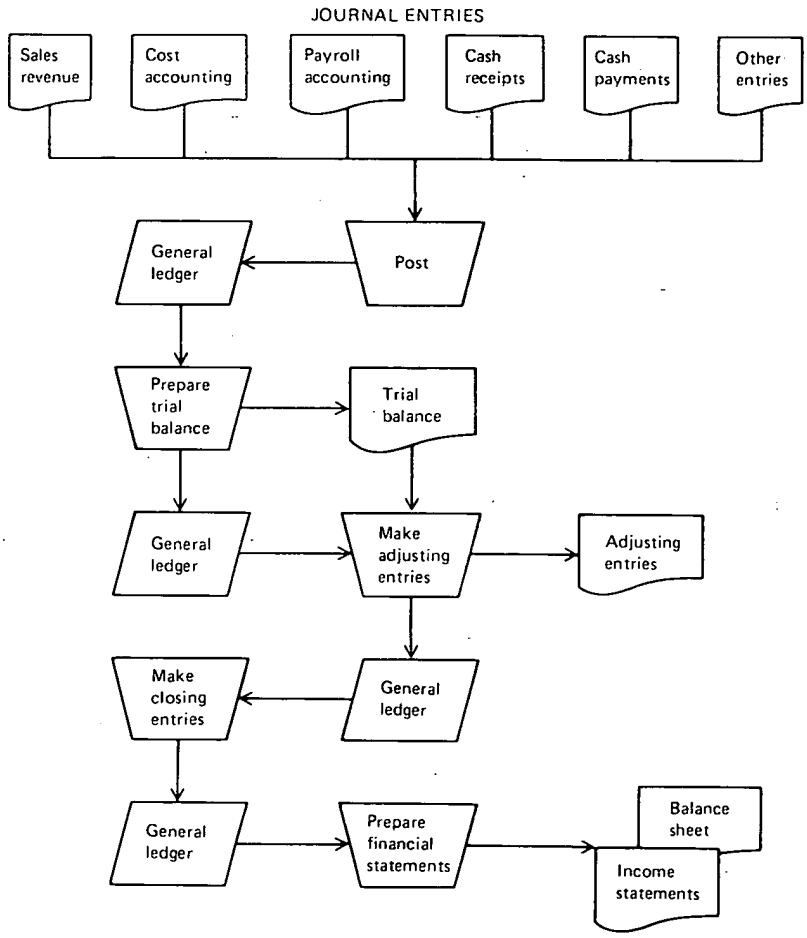


Figure 20.7
Systems flowchart of a manual system for general ledger accounting.

Once any errors have been corrected, the general ledger clerk prepares all adjusting entries and posts these to the general ledger. At the end of each fiscal year, entries to close all revenue and expense accounts are made and posted. The final step in the process is preparing financial statements, including the balance sheet and income statement.

Control Objectives and Procedures

Internal control procedures within the finance cycle must be designed to give assurance that

1. All cash receipts, cash disbursements, fixed asset transactions, and accounting journal entries are properly authorized on the basis of established criteria.
2. Cash and fixed assets are properly safeguarded.

3. All valid cash, fixed asset, and accounting transactions are accurately recorded and processed.
4. Accurate accounts receivable, accounts payable, fixed asset, and general ledger records are maintained.
5. Cash and fixed assets are prudently and productively used.

This section reviews internal control procedures designed to achieve these objectives within the context of the various manual systems for financial data processing just described.

The Cashier is responsible for authorizing the deposit of cash receipts in the bank. To provide for maximum accountability for cash receipts, an organization should have a policy that all checks and currency received each day are deposited intact in the bank. Checks received in the mail should be stamped "for deposit only" immediately upon receipt in the mail room and then batched, listed, and totaled. Cash received over the counter should be recorded on a cash register, and the amount of cash in the register should be reconciled periodically with the cash register record of cash received. At least once each day, all checks and currency received should be transmitted to the Cashier, who endorses all checks, prepares a deposit slip, and deposits the entire amount in the bank. These procedures ensure the creation of two independent records of all cash received: the record prepared prior to transmittal of receipts to the Cashier and the bank's record of the deposit.

Cash disbursement authorization procedures are the responsibility of the Accounts Payable department. As indicated in the description of the manual system, authorization is based on a comparison of vendor invoices with purchase orders and receiving reports, or on a review of vendor invoices for proper approvals by responsible officials. Accounts payable personnel document each payment authorization by preparing a disbursement voucher, which in turn is reviewed by the Cashier prior to issuance of a check.

Special procedures should be employed for authorizing sales returns and allowances, bad debt write-offs, and purchase returns and allowances. In each case, authorization should be the responsibility of a designated official. This person should be someone who is organizationally independent of the accounts receivable and accounts payable functions, which are responsible for recording these transactions. A special form should be prepared, indicating the reasons for the transaction and documenting its approval. The documentation should be reviewed, and the appropriate approvals verified, before the transactions are recorded in the accounts receivable or payable records.

Authorization of fixed asset acquisitions is a managerial responsibility. As indicated in the system description, lower level managers are generally authorized to purchase fixed assets costing up to a specified dollar amount. The purchase of assets costing more than that amount must be authorized by top executives. In each case, approval must be based on a written analysis of the costs and benefits of acquiring the asset.

Journal voucher documents authorize the making of journal entries. Journal vouchers are prepared and approved by authorized personnel in Billing, Cost

Accounting, Accounts Payable, and other accounting departments. General ledger clerks then check each journal voucher for the proper approvals before posting the entries to the general ledger.

A variety of procedures are employed to safeguard cash. Most important are procedures designed to provide an accurate record of all cash receipts and disbursements, and to provide accountability for the cash amounts recorded. To the extent possible, given the nature of the business, the handling of money within the organization should be minimized. A checking account should be used so that all cash transactions are recorded in both company and bank records. Mail room listings of cash receipts should be reconciled with bank deposits, and cash register records of cash receipts should be reconciled with the amount of cash in the register. Access to blank checks should be restricted. Checks should be sequentially prenumbered, and the Cashier or another designated official should regularly verify that all checks are properly accounted for. A bank reconciliation should be prepared each month to verify that the company's cash records are consistent with those of the bank. Petty cash funds should be no larger than necessary and should be controlled using the imprest system.

Separation of functions is another important aspect of internal control for purposes of safeguarding cash. The recording of cash receipts should be performed by mail room personnel, by retail sales personnel utilizing cash registers, and by accounts receivable personnel. The recording of cash disbursements should be performed by the Accounts Payable department. These recording functions must be organizationally independent of the function that has custody of cash—that of the Cashier. Custodial functions performed by the Cashier include endorsing and depositing cash receipts in the bank and preparing, signing, and distributing checks. Internal control is further enhanced by having the bank reconciliation prepared by someone who is organizationally independent of both the recording and custodial functions.

Procedures for safeguarding fixed assets include (1) plant security measures that restrict access to facilities to authorized personnel at authorized times, (2) assignment of accountability for each asset to a specific manager, (3) approval and documentation of all asset acquisitions, transfers, and disposals, (4) taking of a periodic inventory of assets on hand, which is reconciled with the fixed asset records, and (5) maintenance of adequate insurance coverage on all facilities and equipment.

Procedures for assuring that transactions are accurately recorded and processed include assigning responsibility for the preparation of accurate source document records to qualified employees, reviewing and reconciling source documents and related records during processing, and using batch totals. For example, mail room personnel must compare the amount of each receipt with the accompanying remittance advice. Accounts receivable clerks must compare each remittance amount with the accounts receivable balance due. Accounts payable clerks must reconcile each vendor invoice with the related purchase order and receiving report. Batch totals of cash receipts and cash disbursements should be prepared in the early stages of processing and checked against totals generated at subsequent stages. With respect to the general ledger, regular confirmation that total debits equal total credits represents a special type of batch total check.

To ensure that accurate records of accounts receivable, accounts payable, fixed assets, and general ledger accounts are preserved, the recording and custodial functions should be organizationally independent, as described above. In addition, the receivables, payables, and fixed asset subsidiary ledgers should be reconciled periodically with the corresponding general ledger control accounts. Also, subsidiary ledger records should be reconciled periodically with actual amounts, through such methods as taking an inventory of fixed assets and requesting confirmation of current balances due from a sample of customer and supplier accounts.

Management controls designed to assure that cash is used prudently and productively begin with cash budgeting procedures that provide precise estimates of cash inflows and outflows based on current receivables, payables, purchase commitments, and other anticipated receipts and obligations. An effective budgeting system enables management to consistently take advantage of cash discounts for prompt payment of suppliers, to plan fixed asset acquisitions and other major expenditures at the most advantageous times, to arrange for any necessary short- and intermediate-term borrowing at the best possible terms, and to invest any excess cash balances at the best available return.

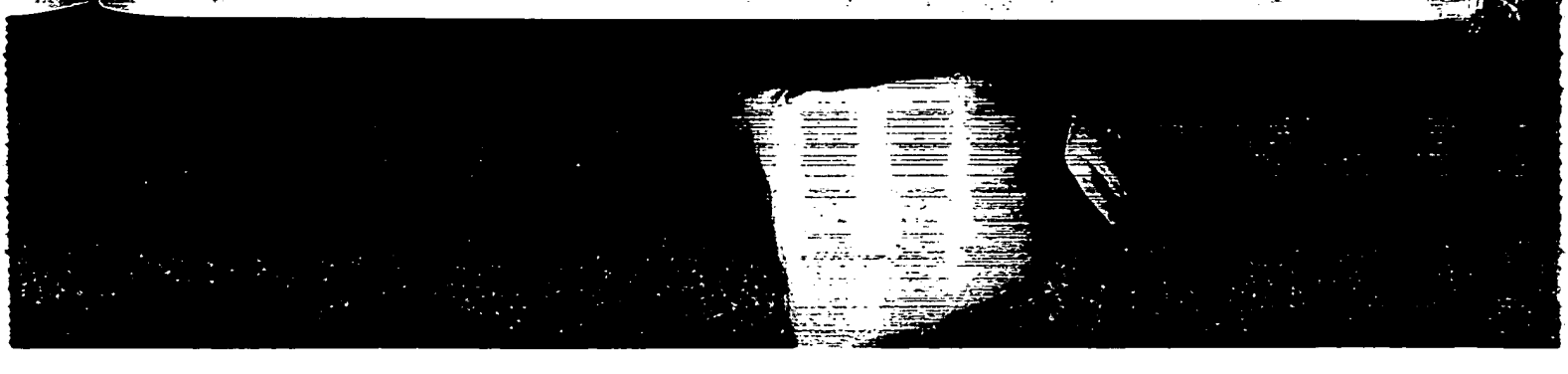
The prudent and productive use of fixed assets is enhanced by assigning responsibility and accountability for each asset to appropriate supervisory and managerial personnel. An important part of this responsibility is recommending (and justifying) replacement of equipment and facilities when necessary. Financial controls include charging depreciation against each manager's budget and utilizing financial performance measures (such as return on assets or return on investment) that incorporate measures of asset value. In addition, preventive maintenance of facilities and equipment should be carried out regularly, and all repairs and maintenance should be performed only by qualified personnel.

Computer-Based Financial Information Systems

If a computer is employed in financial data processing, many of the operations illustrated in Figs. 20.4, 20.5, and 20.7 may be automated. This section describes and illustrates a variety of ways in which computer-based systems may be employed to process financial data and generate information for financial management. Consistent with previous chapters, the material is presented in five subsections dealing with data capture, transaction processing, file maintenance, control objectives and procedures, and reporting.

Data Capture

This section describes methods of capturing, in machine-readable form, transaction data on (1) cash receipts, (2) fixed asset acquisitions, improvements, and retirements, and (3) accounting journal entries. Input data relating to cash disbursements are entered into the system as the vendor invoices are received and approved, as described in Chapter 17.



The data that a cash receipt record must contain include the customer account number, invoice number, date received, and amount received. The record might also include a transaction date and other data about the original transaction, though these generally are not an essential part of the input record because they are already in the organization's customer data base and may be accessed via the account number. One way of entering cash receipts data into the computer is by means of online keying from remittance advice source documents. There are, however, a number of alternative methods whereby the data are captured in machine-readable form automatically. For example, utility companies, department stores, and bank credit card establishments use turnaround documents printed in machine-readable form, which are mailed to the customer with the bill and then returned with the customer's payment as a remittance advice. Alternatively, customers may be asked to send payments to a bank lockbox service, in which case the cash receipts data are transmitted in machine-readable form from the bank's computer to the seller's computer. Another possibility involves the use of electronic funds transfer, in which the remittance and related data are transmitted electronically from the buyer to the buyer's bank and from there to the seller's bank, which deposits the payment in the seller's account and transmits the remittance data to the seller's computer. Finally, in retail establishments that use point-of-sale devices, cash receipts data are captured automatically by these devices when they record collections from customers for merchandise purchased.

Fixed asset acquisition and improvement records include data on the total cost, date installed, installation cost, asset description, location, depreciation method, useful life, and so forth (see Fig. 20.3). Although these data input requirements are extensive, most companies generally do not have a large number of asset acquisitions and improvements at one time; therefore, it is not essential that fixed asset acquisition data be captured in machine-readable form. In most cases, these data are entered into the system by accounting staff personnel using online terminals. Data on the disposal of fixed assets through retirement or sale are also entered into the system in this manner.

With respect to data capture, accounting journal entries fall into one of three categories. First, summary journal entry records for routine transactions involving sales, inventory, payroll, and cash receipts and disbursements are created automatically as a by-product of computer processing, as depicted in Figs. 16.8, 16.9, 17.8, 18.12, and 19.6. Second, routine adjusting and closing entries are generally made automatically by the computer as part of the month-end closing process. Third, entries for nonroutine transactions such as asset retirements, new bond or stock issues, account write-offs, and investments in debt or equity securities, as well as certain nonroutine month-end adjusting entries, are keyed in by accounting staff personnel using online terminals.

Transaction Processing

This section describes transaction processing procedures used for cash receipt transaction records, fixed asset transaction records, and accounting journal entry records. Transaction processing for cash disbursement records consists of the

procedures employed for review and verification of vendor invoices, as described in Chapter 17.

Transaction processing procedures for cash receipt records are depicted in Fig. 20.8. The figure shows remittance records originating in many of the ways described in the previous section, though not all of these data capture methods would necessarily be used by a single company. For all remittances received by mail, the amount received must be checked for agreement with the amount indicated on the remittance advice document prior to processing. If remittance records originate from more than one source, the first step in processing is to merge the separate remittance input files into a single remittance transaction data file. Each remittance input file should have a control record indicating its source, the number of records, the total dollar amount of remittances, and perhaps a hash total of the customer account numbers.

On a periodic basis, such as once each day, the merged remittance transaction

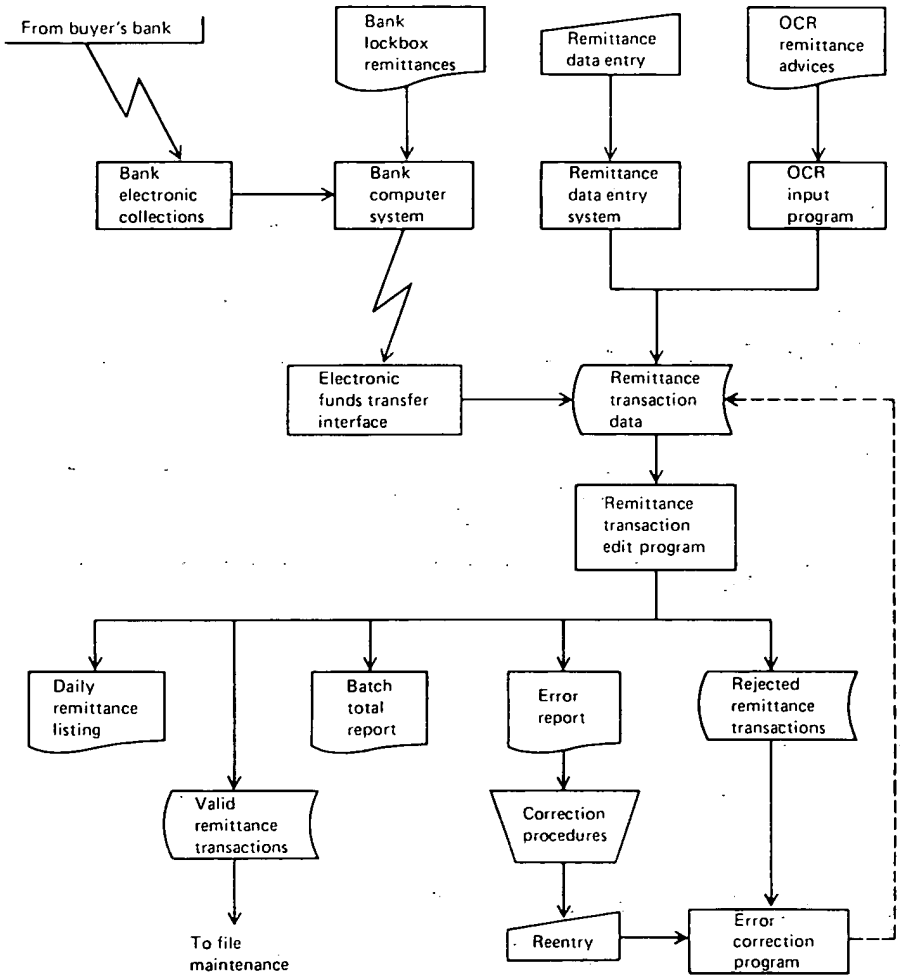


Figure 20.8 *Cash receipt transaction processing.*

data file is processed by an edit program. This program performs various edit checks on the data, including field checks for numeric data in all numeric fields, check digit verification or other validity checks of the customer account number, a range check on the receipt date, a limit check on the amount received, and a completeness test of each record. Any transactions rejected by these edit checks are listed on an error report and on a temporary disk file. These should be promptly examined, and corrections entered using an online terminal. The corrected records are then written onto the next day's remittance transaction data file.

All transactions passing the edit checks are written onto a temporary disk file and printed in a daily remittance listing. Batch totals are computed and checked against those in each input file control record, and a batch total report is printed. The input file is then sorted by account number in preparation for processing to update the customer master file.

For fixed asset transaction data, transaction processing procedures are performed by an online data entry program which interacts with accounting personnel as they enter data. A simplified data entry technique such as preformatting or prompting should be used. The system performs various edit checks on the input data and displays a message requesting confirmation or correction of any questionable data. At the conclusion of the data entry process, a printed listing of all transaction data is prepared for review by supervisory personnel. The fixed asset transaction records may be processed to update the master file at this time, or they may be stored on a temporary input file to be processed subsequently by a file update program.

Different transaction processing procedures are employed for routine and nonroutine accounting journal entry transactions. Routine entries generated as a by-product of other accounting processes may be processed directly to update the general ledger master file, without any intervening transaction processing steps. Alternatively, such entries may be recorded on a temporary disk file, subject to review, adjustment and approval by an accounting supervisor prior to general ledger update. Nonroutine transactions are entered using an online data entry program and then submitted to the same types of transaction processing procedures as fixed asset transaction records (described in the preceding paragraph).

File Maintenance

This section describes and illustrates batch processing procedures employed (1) to update the accounts receivable master file for cash receipts, (2) to process cash disbursements and update the accounts payable master file, and (3) to update the fixed asset master file for asset acquisition, improvement, and retirement transactions. Online processing is generally not used for these procedures, because instantaneous processing of these transactions offers little advantage and it is not essential that the related master files be completely current at all times. The section also describes batch and online processing procedures for general ledger accounting.

Figure 20.9 is a systems flowchart depicting the processing of cash receipt transactions to update the accounts receivable master file. Cash receipts processing is generally done on a regular and frequent basis, such as daily. The input to this process consists of the validated remittance transaction file produced by the transaction processing program shown in Fig. 20.8. An initial step in this run is to perform those additional validity checks on each cash receipt record that require a comparison of transaction data to master file data. These procedures might include (1) checking that the account number of each transaction record matches one on a master file record, (2) checking that the amount received does not exceed the amount due, and (3) checking that the customer has not deducted a cash discount from the remittance if the payment receipt date is past the account due date. Any transactions not meeting these tests are listed on an error report and written on a separate file, to be dealt with through special correction procedures.

For receipt transactions that pass these validation tests, the program attempts to match the receipt amount with the amount of a specific unpaid invoice, or with the total balance due on account. If no such match can be made, the remittance amount is applied to the oldest outstanding invoice, with any remainder

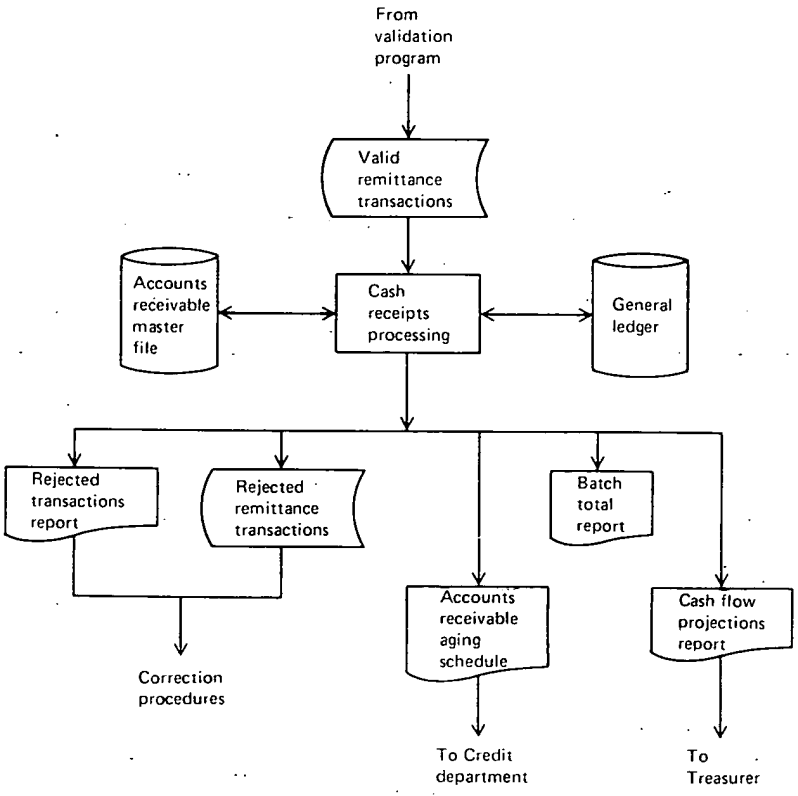


Figure 20.9
Batch processing of cash receipt transactions.

applied to the next oldest invoice, and so on. Invoices paid in full are deleted from the file. The total remittance amount is subtracted from the current balance due on account. Data needed for the summary journal entry, the batch total report, and the cash flow projections report are accumulated by the program during the run.

On a weekly or monthly basis, or at the request of the Credit Manager, an accounts receivable aging schedule is prepared. After each customer account has been updated, the remaining unpaid invoices are classified as current (or not past due), one to thirty days past due, thirty-one to sixty days past due, and so forth. Each account that has a nonzero balance is listed on the aging schedule along with the total balance, apportioned among one or more report columns corresponding to the aging categories. File totals for each aging category are accumulated and printed at the bottom of the aging schedule. This report is provided to the Credit Manager for use in establishing and administering the company's credit policies.

At the conclusion of the run, the summary journal entry is posted to the general ledger, and a batch total report is printed. Once each week, or at the request of the Treasurer, a cash flow projections report is printed. A projected collection date is estimated for each outstanding invoice, and then total projected receipts are accumulated by collection date during the run. The report, which lists the total estimated collections for each of the next thirty to sixty days, is furnished to the Treasurer for use in budgeting cash flows.

Figure 20.10 is a systems flowchart showing batch processing of cash disbursements. This process takes place at least once each day. The program begins by scanning the accounts payable master file for invoices due for payment on the current date. Any such invoice records are deleted from the accounts payable master file, and the data necessary to process the payment are recorded on a temporary disk file. This file is input to a cash disbursements processing program. This program determines the payment amount by subtracting any applicable cash discount from the gross invoice amount. If the disbursement is to be made by check, then the check and remittance advice documents are printed. If the disbursement is to be made by electronic funds transfer, then the payment record is recorded on a temporary file of electronic disbursement transactions. A record of each disbursement is then printed on the cash disbursements register.

At the conclusion of the run, the summary journal entry is posted to the general ledger and a batch total report is printed. The checks and remittance advices are assembled for mailing to vendors, and the cash disbursements register is sent to the Controller. The file of electronic disbursements is processed by an electronic funds transfer interface program, which transmits the disbursements to the bank's computer, from which they are transferred electronically to the bank accounts of the various vendors. Notification of payment is sent to each vendor through the electronic funds transfer network.

The processing of fixed asset transactions to update the fixed asset master file may take place as the transactions are entered into the system from online terminals, or it may be accomplished in a batch processing run at the end of each month. In the latter case, transactions are stored on a temporary file, which is

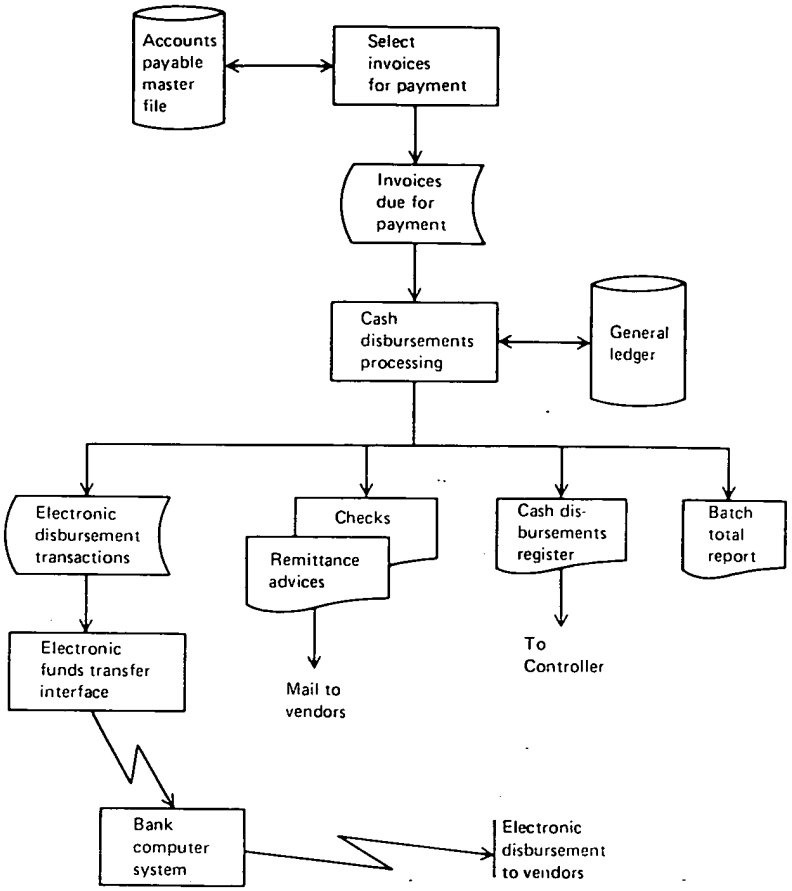


Figure 20.10
Batch processing of cash disbursement transactions.

reviewed and validated prior to the file update. Figure 20.11 is a systems flowchart illustrating batch processing of fixed asset transactions to update the fixed asset master file. It is assumed that all transaction records were fully validated prior to this run. (If they were not, any rejected transactions would have to be corrected and then either processed in a separate and unscheduled update run or delayed until the next month's update run.) The update program modifies existing fixed asset master records for asset improvement transactions, deletes any master records corresponding to fixed asset retirements, and adds new master records for fixed asset acquisitions. The program prints various reports for the Controller, including a fixed asset master file listing, a depreciation summary report, and a fixed asset transaction listing. At the conclusion of the run, the summary journal entry is posted to the general ledger and a batch total report is printed.

The systems flowchart in Fig. 20.12 depicts an online system for general ledger accounting. As explained earlier in the chapter and shown in the flowchart, rou-

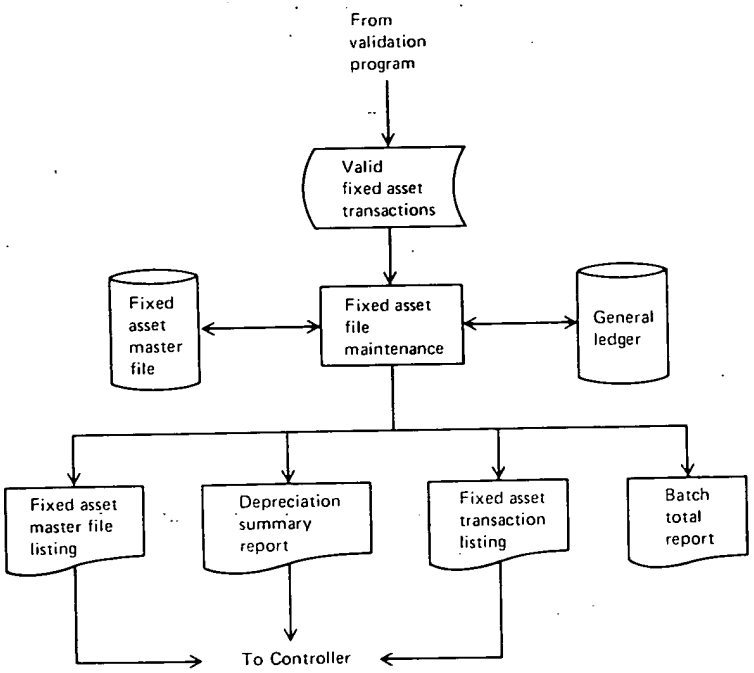


Figure 20.11
Batch processing of fixed asset transactions.

tine accounting journal entries are entered into this system as a by-product of other accounting processes, and nonroutine entries are entered by Accounting department personnel using online terminals. All entries are processed as they occur by an online accounting transaction processor. This program checks for possible errors in each input record, generates a printed listing of each journal entry, and posts each entry to the appropriate general ledger accounts in the financial accounting data base. The printout is transmitted to the Controller for reference and control purposes.

As the flowchart indicates, the financial accounting data base and the related budget master file are processed by several other programs. At the end of each month, the monthly closing program generates adjusting and closing entries, posts these to the general ledger accounts, and prepares a balance sheet, income statement, and other month-end financial statements. Also at this time, this or a related program retrieves budget data from the budget master file, matches these data with actual financial data recorded in the general ledger accounts, and prepares departmental financial performance reports comparing budgeted and actual financial results.

The financial accounting data base and the budget master file may also be accessed by financial decision support system programs and by accounting inquiry processing programs. These programs retrieve financial information for accounting and auditing staff personnel, and prepare a variety of analyses of this information to assist management in financial decision making. Some examples of reports and analyses that may be obtained in this manner are described in the later section on reporting.

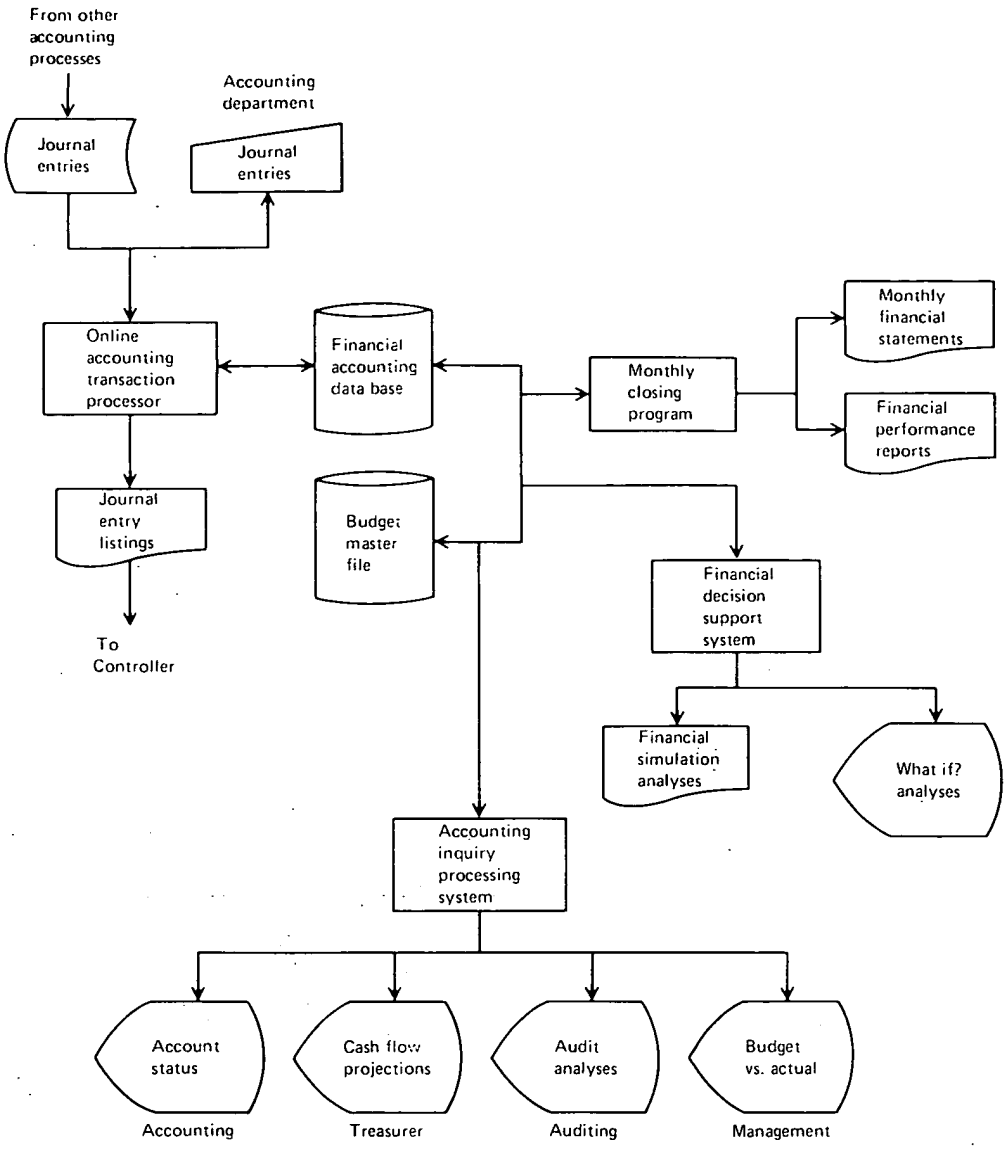


Figure 20.12
Online general ledger accounting system.

Accounting journal entries could be processed in a batch mode. In this case, as journal entries occurred within the system, they would be recorded on a temporary disk file. At regular intervals, possibly once each day but not less often than once each month, the accumulated batch of journal entries would be processed to update the general ledger accounts. Batch processing would not affect

the closing and reporting processes illustrated in the flowchart. Although batch processing might be somewhat more efficient than online processing, it has the obvious disadvantage that the financial accounting data base would be up to date only immediately following a transaction update run.

Control Objectives and Procedures

Earlier in this chapter, five control objectives associated with the finance cycle were identified, and their attainment within the context of a manual system for financial data processing was explained. Although the discussion of computer-based financial data processing systems included a description of some control procedures, it did not address the matter of how these procedures relate to the control objectives. This issue will be briefly addressed here.

The first control objective is to assure that all cash receipts, cash disbursements, fixed asset transactions, and accounting journal entries are properly authorized on the basis of established criteria. The use of computers necessitates little change in transaction authorization procedures with respect to cash received over the counter, checks received by mail, petty cash disbursements, and cash disbursements by check. The processing of cash receipts and disbursements by electronic funds transfer, however, requires that special attention be paid to internal control.

Before committing an organization to the use of EFT, its management must obtain assurance that the bank's computer system and EFT network interface are secure from unauthorized intervention and are subject to regular audits designed to monitor their security. Access to the system should be controlled through the use of account numbers and passwords. A limited number of responsible management officials, such as the Cashier, Controller, and Treasurer, should be authorized to use the system. Each disbursement record should include a code identifying the person who initially authorized the disbursement; this person would generally be the accounts payable clerk who approves vendor invoices for payment. A separate person, such as the Cashier, should be responsible for reviewing all authorized disbursements and issuing final approval before they are released to the EFT network. For special transactions, such as all disbursements in excess of $10,000, an additional authorization code should be required. Before transactions are processed, the network software should review each transaction record for the presence of the proper authorization codes.

The use of computer-based systems often means that transaction data relating to fixed asset transactions and accounting journal entries are entered into the system through online terminals. Although this method of data capture does not affect the authorization criteria and the procedures associated with the initiation of these transactions, it does affect the procedures for recording the transactions and documenting their authorization. Specifically, access controls similar to those described in the preceding paragraph are called for. To control accounting journal entries that originate automatically as a by-product of other accounting processes, an organization must maintain adequate control over the development and

modification of the accounting programs that initiate these entries. The system should prepare a transaction listing of all fixed asset transactions and accounting journal entries initiated automatically or through online terminals. This report should be promptly transmitted to the Controller, who should check that each listed transaction is proper and has been appropriately authorized.

The second control objective is to assure that cash and fixed assets are properly safeguarded. The use of computers supports the achievement of this objective by enabling more accurate and current records of cash and fixed assets to be maintained and by facilitating regular comparisons of these records with actual amounts on hand. For example, listings of fixed assets by responsibility center can be prepared regularly and furnished to departmental managers to enhance accountability. In addition, the computer can be programmed to prepare monthly bank reconciliations. Control procedures associated with transaction authorization, as described earlier, are essential to the safeguarding of cash receipts and disbursements by EFT.

The third control objective is to assure that all valid cash, fixed asset, and accounting transactions are accurately recorded and processed. This objective is accomplished through the use of several techniques that have already been described, including batch totals, edit programs, input validation routines incorporated within online data entry programs, and automatic capture of transaction input data as a by-product of other accounting processes.

The fourth control objective is to assure that accurate accounts receivable, accounts payable, fixed asset, and general ledger records are maintained. The focal point here is maintaining the integrity of the various data bases that contain these records. For this purpose, a number of data security controls are used, including internal and external file labels, proper file backup procedures, and offsite storage of backup files. Also of critical importance are the access control procedures described earlier in this section. In addition, the computer should be programmed to frequently reconcile all accounting subsidiary ledgers with the corresponding general ledger control accounts, and to continuously maintain a balanced general ledger. Finally, regular comparisons of these various accounting records to actual values are facilitated by using the computer to prepare bank reconciliations, account confirmations, and departmental fixed asset listings.

The fifth control objective is to assure that cash and fixed assets are prudently and productively used. Computers can be used in a number of ways to help achieve this objective. A computerized accounts payable system may be programmed to ensure that vendor invoices are paid in time to earn any cash discounts offered for prompt payment. A computer-based accounts receivable system monitors collections and promptly reports on any customer accounts needing attention because of slow payment. A computer-based accounting and budgeting system enhances the productive use of cash by providing continuously current information on past and projected cash flows. The productive use of fixed assets is similarly enhanced by a computer-based fixed asset accounting system that monitors and reports on the need for equipment maintenance, repairs, and replacement. Computer-based financial reporting systems provide incentives for productive asset utilization by employing departmental performance measures

that incorporate measures of asset value, such as return on assets or return on investment.

Reporting

The use of computers in financial data processing facilitates the preparation of various scheduled, triggered, and demand reports designed to enhance the effectiveness of the financial management function. Many such reports have been mentioned in preceding sections. This section describes some examples of these and other typical financial reports in greater detail.

The number of scheduled financial reports mentioned in earlier sections of this chapter is too large to permit a full description of each one here. These reports are readily identified by referring to Figs. 20.8 through 20.12. The general nature and purpose of most of these reports is evident from the brief descriptions already given. Two examples will be illustrated and described more fully here.

The **cash disbursements register** is a list of all payments—by check or EFT—made by the daily cash disbursements processing procedure (see Fig. 20.10). It is sometimes referred to as a check register, but the growth of EFT as a means of payment has made this label obsolete. For each disbursement, this report lists vendor information; disbursement details, such as method of payment and check number or vendor bank account number; gross invoice amount; cash discount; and net amount disbursed. At the end of the report, the total gross, discount, and net amounts are printed, along with a breakdown of the net amount by disbursement mode (check or EFT). An example of a cash disbursements register appears in Fig. 20.13. This report is useful to the Controller for reference purposes and is a key part of the audit trail for cash disbursement transactions.

Departmental financial performance reports compare actual and budgeted costs for each production, service, and administrative department in the organization. These reports are generated monthly, at the conclusion of the general ledger closing and financial statement preparation process (see Fig. 20.12). An example of such a report for a factory production department appears in Fig. 20.14. For such a report to be generated, all cost and budget data must be accessed by department number and cost type. For this purpose, the general ledger account coding system (the chart of accounts) must contain subcodes for both department number and account type (as illustrated in Figs. 3.11 and 3.10, respectively). By aggregating cost and budget data over all departments reporting to a particular supervisor, the system can generate similar financial performance reports for each higher level of management (see Fig. 2.5). Financial reports of this type provide information of critical importance in evaluating the performance of departmental supervisors and managers.

Inquiry processing is often employed to extract useful administrative and management information from various financial data bases. For example, accounting staff personnel frequently must examine the current status of a specific account or transaction in response to a request from management, a customer, or a sup-

CASH DISBURSEMENTS REGISTER

Date: January 11, 1989 Time: 10:38:09

Control number	Vendor number	Vendor name	Disbursed by	Accounts payable dr.	Discount cr.	Cash cr.
38729	632845	National Supply	Check = 10451	$ 512.67	$ 10.25	$ 502.42
38730	176413	Ross Mfg. Co.	Check = 10452	$ 95.07	$ .95	$ 94.12
38731	415242	Northern Metals	EFT = 5437-641092	$ 742.72	$ 14.85	$ 727.87
38732	366021	Webster Bros.	EFT = 4712-286771	$ 4,208.18	$ 84.16	$ 4,124.02
38733	618775	ABX Distribtrs.	Check = 10453	$ 825.30	$ 8.25	$ 817.05

Figure 20.13
Cash disbursements register.

Figure 20.14
Cost performance report for a production department.

OPERATING PERFORMANCE SUMMARY

Department: # 473 Machining Supervisor Oscar Nagursky

Cost element	Month ending 2/28/90			Year to date		
Controllable overhead	Budget	Actual	Over (under) budget	Budget	Actual	Over (under) budget
Indirect labor	$4,750	$4,608	$(142)	$9,300	$9,248	$(52)
Idle time	250	304	54	480	502	22
Tools and supplies	880	856	(24)	1,720	1,702	(18)
Maintenance	750	802	52	1,450	1,638	188
Rework	120	70	(50)	230	180	(50)
Miscellaneous	200	230	30	380	370	(10)
Total controllable overhead	$6,950	$6,870	$(80)	$13,560	$13,640	$80
Direct labor	$13,200	$13,256	$56	$26,000	$26,384	$384

plier. Internal or external auditors may want to retrieve information regarding financial trends or relationships in order to determine which accounts require more extensive audit scrutiny. Management may desire interim reports comparing actual and budgeted costs for specific executives or projects. The Treasurer may wish to retrieve information useful in monitoring corporate cash flows on a daily, or even hourly, basis. An inquiry processing system that can respond to these and other similar requests on a timely basis is an essential component of any modern financial information system.

Triggered reports may also be employed in financial information systems. One example would be a report identifying prospective cash flow shortfalls. As sales, purchases, cash receipts, and cash disbursements are processed, cash flow projections incorporated into the master budget may be updated. If the cash flow effects of these various transactions deviate from expectations, the organization could face an unanticipated shortage of cash. The budgeting system could be programmed to identify any projected cash flow shortfalls as soon as they become apparent, based on a continuously revised cash budget. This condition would trigger a report that would be sent to the Treasurer.

Financial performance reports for departments or projects might also be triggered under special conditions. Under normal conditions, these reports are usually prepared on a monthly basis. If production costs in a factory department suddenly began to exceed standards by more than some preset average (such as 10 percent), however, the system could be programmed to prepare an interim financial performance report for management's immediate attention. Similarly, if actual costs suddenly began to exceed budgeted costs for a marketing research project, a software development project, or a product development project, the system could prepare an interim project cost analysis for management's attention. These are good examples of ways an information system can be designed to support application of the principle of management by exception.

An expert system may be used to assist financial executives in managing the organization's investment portfolio. Such a system would employ knowledge bases on current economic conditions and on the general suitability of various categories of investments (for example, Treasury bills or blue-chip stocks). The economic conditions knowledge base would be continuously updated to reflect current economic trends. The system would interact with a designated financial executive who specified the organization's investment goals. Based on these specifications and its knowledge bases, the expert system would prepare recommendations as to the proportions of the investment portfolio that should be allocated to each investment category. This system might be integrated with the organization's cash budgeting system so that factors associated with investment timing could be taken into account.[2]

Decision support systems are commonly used by management in the analysis

[2]A similar system designed to support investment analysis by an individual investor is described in Barry Shane, Mitchel Fry, and Reuben Toro, "The Design of an Investment Portfolio Selection Decision Support System Using Two Expert Systems and a Consulting System," *Journal of Management Information Systems* (Spring 1987): 79–92.

of financial information to support decision making. Even before the advent of microcomputers in the early 1980s, some firms were using mainframe-based decision support systems that employed financial planning models. As the use of microcomputers in business organizations became widespread, financial planning emerged as one of the most popular uses of microcomputer spreadsheet packages, graphics packages, and statistical modeling programs. In a typical application, a portion of the financial data base, including selected budget data, is downloaded to a personal computer file. A decision support system is used to simulate the company's operations and related cash flows over the next six to eighteen months. Such a system normally includes a "what if?" capability that enables the user to examine the possible effects of changes in key financial policies, conditions, or assumptions underlying the model. For example, the user might wish to examine what would happen to cash flows or other key operating variables if a major customer failed, or if product prices were reduced by 5 percent, or if sales of a new product fell 20 percent below projections. The decision support system simulates the company's operations under the revised conditions and prepares a report analyzing the projected effects on the specified variables.

These examples illustrate how the power of computers can substantially improve the quality of the financial information available to support management decision making. Scheduled reports can provide large volumes of information for reference purposes and also summarize this information according to various decision-relevant criteria. Triggered reports can highlight information about specific conditions or transactions that call for prompt management attention. Demand reports can provide specific information relevant to a particular management purpose. A well-designed financial information system uses all of these tools to enhance the effectiveness of the financial management function.

Summary

Finance cycle activities include arranging sources of capital funds for the organization, maintaining relationships with investors and creditors, planning capital expenditures, establishing credit and collection policies, securing appropriate insurance coverage, planning and controlling cash flows, and evaluating the financial performance of managers and organizational units. Related data processing operations include managing the receipt and disbursement of cash, maintaining general accounting records, and preparing budgets, financial performance reports, and financial statements. The accounting information system plays a central role in carrying out these data processing operations and in supplying financial information to management.

Financial data processing operations may be performed either by manual accounting systems or by computer-based systems that operate in either a batch processing or an online processing mode. Manual accounting systems are based on traditional double-entry accounting techniques and employ journals to record transactions and ledgers to keep track of current account balances. Computer-based systems not only can handle these traditional accounting operations much

more efficiently, but also facilitate generation of the large volumes of accounting information needed to support effective financial management.

REVIEW QUESTIONS

1. Define the following terms:

finance cycle	general ledger
treasurership	subsidiary ledger
controllership	journal
Chief Financial Officer	remittance advice
adjusting entries	disbursement voucher
closing entries	debit distribution
ledgers	cash disbursements register

2. Describe or illustrate an example of a typical organization structure for the financial management function. What are the primary decision responsibilities and information requirements of the financial management function?

3. Which accounting journal entries summarize the data processing activities involved in

a) cash receipts
b) cash disbursements
c) recording of costs and expenses
d) maintenance of fixed asset records
e) financial statement preparation at the end of a month

4. Describe the content and organization of a financial accounting data base.

5. What should be the relationship between a general ledger control account and its corresponding subsidiary ledger? List some examples of accounts for which subsidiary ledgers are commonly maintained.

6. What is the relationship between the accounting concepts of ledger and journal and the information systems concepts of master file and transaction?

7. In traditional accounting systems, journalizing and posting are separate operations. Explain how these procedures can be integrated into a single operation with data base technology.

8. Which departments in a business organization are typically involved in manual processing of (a) cash receipts and (b) cash disbursements? For both cases, what documents are typically used and what data does each document contain? In which department does each document typically originate, and where and for what purpose would it be distributed?

9. What procedures might a retail organization establish to record and control cash sales?

10. Describe the imprest petty cash system. Indicate in your description the most significant control procedures in the system.

11. Describe the key features of a typical manual system for maintaining fixed asset records.

12. Describe the key steps in a manual system for general ledger accounting.

13. What are the objectives of internal control procedures used in a manual system for financial data processing? Identify specific control procedures designed to accomplish each objective.

14. Explain the commonly used methods of capturing, in machine-readable form, input data on (a) cash receipt transactions, (b) fixed asset transactions, and (c) accounting journal entries.

15. For a computer-based system, describe the transaction processing procedures typically employed for (a) cash receipt transactions, (b) fixed asset transactions, and (c) accounting journal entries.

16. Describe the steps in computer-based batch processing of (a) cash receipt transactions, (b) cash disbursement transactions, and (c) fixed asset

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